THREE ESSAYS ON APPLIED CONTRACTING

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ABSTRACT

In the first and second essays, I use economic models of relational contracting to assess the potential economic impact of proposed legislation that would require processors to pay termination damages to growers when contractual relationships are prematurely terminated. Asset specificity, ex post bargaining power on the part of processors, and an exogenous shock that undermines gains from trade are introduced into the models. In the first essay, I assume that processors and growers can initiate relational contracts based on some observable, but non-verifiable, performance measure. I conclude that under symmetric information about an exogenous shock, termination damages would not be distortionary and would not undermine processors' ability to design effective incentives. Therefore, termination damages do not affect growers' expected payoffs in optimal relational contracts. However, under asymmetric information about an exogenous shock, termination damages can either increase or reduce growers' expected payoffs.

In the second essay, I assume that performance measures are subjective in the sense that the processor and grower may not necessarily agree on measured performance outcomes. I show that while contract termination is used as an incentive device, pay for performance is no longer used. Under symmetric information about an exogenous shock,

government imposed termination damages would not be distortionary and would induce only a restructuring of the compensation plan.

In the third essay, I present results from an experiment that investigates the existence and causes of self-serving bias and the effect of this bias on subjects' strategic behavior in a multi-period incomplete contracting game. The data shows that self-serving bias exists in the aggregate and is caused by substantial heterogeneity in subjects' responses to unenforceable contract terms. Self-serving bias has no significant direct effect on subjects' contract rejection decisions, but it does have a significant effect on the surplus generated from a contract conditioned on acceptance. My results suggest that economic factors, such as the history of payoffs, are more important *direct* causes of bargaining impasses than are psychological factors, such as self-serving bias, but that self-serving bias indirectly contributes to these impasses.

Dedicated to my family

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CHAPTER 1

INTRODUCTION

Agribusinesses are increasingly relying on contracts to source and market agricultural commodities. While contracts enable firms (i.e., integrators or processors) to better coordinate the supply chain from the farm gate down to the retailer, many growers, farm advocacy groups, and policy makers have become concerned that contracts may be oppressive to growers (Wu, 2003). One stylized fact that is frequently observed in the livestock sector (e.g. broilers and hogs) is that, in order to secure a contract, growers are often required to make substantial investments in new production facilities (Lewin-Solomons, 2000). These facilities are often relationship-specific as they must meet the exact requirements of each processor and often force growers into debt as they can cost hundreds of thousands of dollars to build.[1] At the same time, processors do not always provide growers with explicit written agreements about the duration of the contract or provisions for termination and renewal, leaving growers vulnerable as the relationship with the processor may end before all debts are paid. Consequently, many lawmakers in various states have proposed legislation to protect farmers from undue termination or non-renewal of contracts by providing farmers with the right to be "…reimbursed for

[1] According to Charman (2002), growers must borrow approximately $125,000 per chicken house to build facilities according to the poultry company's specification.

damages incurred due to termination, cancellation, or failure to renew. Damages shall be based on the value of the remaining useful life of the structures, machinery, or equipment involved."[2] If implemented, such legislation essentially imposes a "severance payment" on agricultural contracts in an effort to protect growers.

Because agricultural contracts typically contain both explicit (e.g. written clauses and payment terms that are legally enforceable) as well as implicit components (verbal agreements and understandings and payment terms that are not legally enforeacble), textbook principal-agent models of contracting may be inadequate for dealing with questions pertaining to government intervention in agricultural contracting relationships. Implicit or relational contracts (Levin ,2003; Macleod and Malcomson, 1989) are increasingly recognized by economists as important trade mechanisms in environments where certain aspects of performance are difficult for third parties to verify. Relational contracts also fit many of the stylized facts of livestock contracting. Although explicit contract terms exist to govern short-term obligations and payment terms, an integrator's contract renewal policies are often based on implicit agreements made with growers and aspects of performance such as growers' degree of cooperation with the integrator, growers' willingness to remain flexible and upgrade facilities at the integrator's request, etc., which are difficult for third parties to verify. In some cases, even explicit written agreements may be difficult to enforce. For example, processors in some livestock sectors weigh the animals themselves and determine mortality rates without a third party

[2] Senator Tom Harkin (Iowa) introduced the Agricultural Producer Protection Act (S-2343) to the 106th Congress in 2000, but the bill died. It was subsequently repackaged by Tom Daschle (South Dakota) in the 107th Congress and called the Securing the Future for Independent Agriculture Act of 2001 (S-20). Many states have also proposed new regulations. An example is the Producer Protection Act proposed by Iowa Attorney General Tom Miller and 16 other state attorneys general.

present (Hamilton, 1995), so that quality is difficult to enforce even if an explicit contract contains payment schedules that are contingent on quality. In this case, an integrator has the power to renege on promised bonuses or premiums by not reporting quality truthfully.

The purpose of this essay is to analyze the potential impact of government-imposed breach damages on incentive design, efficiency, and the distribution of surplus between processors and growers. In doing so, I begin by providing an analysis of optimal relational contracts and extend the work of Levin (2003) by introducing ex post bargaining power on the part of the principal, asset specificity for investments made by agents, and an industry-wide exogenous shock that affects productivity of contractual relationships. This analysis provides a basis for understanding the optimizing behavior of the contracting parties under a set of assumptions that are consistent with stylized facts in agricultural contracting. This then provides a coherent framework for assessing the impact of termination damages on optimal contract structure, incentive provision, social efficiency, and the distribution of surplus. Note that I do not address questions concerning the political economy of government legislation and do not address positive issues such as why the government seeks to propose termination legislation. I focus strictly on the efficiency and distributional consequences of such legislation if it is imposed.

The introduction of the principal's ex post bargaining power is particularly important for modeling agricultural contracting problems, as processors often hold monopsony power in input markets and therefore may hold most of the bargaining power.[3] Farmers are often required by processors to make expensive investments in new equipment and housing facilities that meet the exact specifications of processors, so asset specificity becomes a concern. The introduction of an exogenous shock allows us to incorporate termination into optimal contracts. An industry-wide negative exogenous shock is assumed to undermine future surplus from contractual relationships; thus, a processor terminates its contractual relationships with growers. An example is that a negative downstream demand shock may force processors to close processing plants and "lay off" growers. I explore two different information environments with regard to the exogenous shock. First, I assume that there is symmetric information about the exogenous shock in the sense that both processor and grower know the true probability of a negative shock. Second, I assume that there is asymmetric information about the exogenous shock in that the processor and grower do not know the true probability of a negative shock, holding only subjective probabilities concerning the likelihood of a bad shock, and that the processor's assessment is more accurate because it possesses a larger information set than does the grower's concerning the negative shock.

These three extensions affect the self-enforceability of relational contracts and can have consequences for incentive design, efficiency, and distribution. Ex post bargaining power combined with asset specificity enables a processor to reduce the amount of rents paid to growers ex ante to maintain a self-enforcing relational contract and, at the same time, makes growers vulnerable ex post to termination. Especially in the second case of the exogenous shock, a processor will design an incentive scheme that exploits her better

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[3] Farmers' Legal Action Group, Inc. (2001) reports that in the broiler industry, the average number of companies (i.e., integrators or processors) operating in a grower's area is 2.48 and this number has been declining. It also reports that about 28 percent of growers have only one company active in their area.

information about the exogenous shock for her own advantage. While this may increase the efficiency of contractual relationships in some cases, this always distributes surplus from contractual relationships in a manner unfavorable to growers, which implies that growers' expected payoffs may be less than their best outside-relationship payoffs. That is, asymmetric information about an exogenous shock distorts the distribution of surplus from contractual relationships.

Surprisingly, in the case of symmetric information about an exogenous shock, the results show that government regulation of contracts via termination damages would not reduce a processor's ability to design effective incentives and would therefore not be distortionary. Government imposed termination damages do not affect a processor's and a grower's expected payoffs considering the payoffs that both parties earn before and after the termination of a contractual relationship. However, regulation would cause rational processors to factor into their contract design problem the expected future liabilities from termination. As such, growers can expect to earn less per period before contractual relationships are terminated when a termination damages law is passed. Nonetheless, such a regulation protects growers by compensating them for the lost value of their relationship-specific assets after contractual relationships are terminated. In the case of asymmetric information about an exogenous shock, the results show that government regulation of contracts via termination damages seems not to reduce a processor's ability to design effective incentives and therefore need not be distortionary. However, a processor will default on her obligation of making promised payments because she can earn more by doing so. Then, growers earn either more or less under the regulation than under no regulation. This implies that government regulation of contracts via termination damages either mitigates or aggravates the distortion of distribution of surplus that is caused due to asymmetric information on an exogenous shock. These results show that before policy-makers adopt regulation such as termination damages, they need to investigate the distributional consequences more carefully.

CHAPTER 2

MODEL

2. 1. Model Assumptions

An infinite horizon principal-agent relationship between a risk-neutral principal (e.g. food processor or agribusiness firm) and a risk-neutral agent (e.g. grower) is considered. The model of this essay is similar to Levin's (2003) with the exception of three major departures. First, it is assumed that the agent must make a relationship-specific investment at the request of the principal prior to initiating the contract. This imposes an ex post separation cost on the agent because if the agent wants to opt out of the contract or is terminated, it becomes difficult for him to convert his assets to an alternative use. Second, I allow for the presence of ex post bargaining power on the part of the principal. When the principal has ex post full bargaining power, she can costlessly switch to another agent, which constrains the form of the optimal self-enforcing contract. Third, at the end of each period and before the start of the next period, I allow for the possibility that an industry-wide negative exogenous shock (bad state of nature) will eliminate future surplus from contracting. In this case, the principal will exit the industry and sever all relationships with agents. An example might be that a negative downstream demand shock, concerns about the safety of the product, or some other exogenous factors might make it unprofitable for processors to continue operations. In this case, the processor will no longer renew contracts as it will exit the industry. This is essentially a situation where growers might be terminated even if they perform up to expectations. The introduction of this exogenous shock will allow me to analyze recent policy proposals that require processors to compensate growers for relationship-specific investments upon termination or non-renewal of contracts. To facilitate understanding, after developing a relational contracting model without the exogenous shock, I will integrate this shock into the model in a later section.

It is assumed that the principal is attempting to gain a competitive edge in the downstream consumer market by either differentiating its product from those of competitors' or reducing costs in its supply chain by exploiting new technologies or improving coordination, although the exact reason is not specified in order to maintain generality of the model.[4] As an illustration, if a food processor is interested in producing a value-added consumer good that is differentiated from those of competitors, then the processor must consistently source high-quality inputs that may not be obtainable on the spot market. Hence, the processor must contract with individual growers and design a contract that provides adequate incentives for growers to produce high-quality inputs. Relational contracting in this case becomes important if the quality of the input is not verifiable by a third party. For example, some processors in livestock sectors weigh the animals themselves and determine mortality rates without a third party present (Hamilton, 1995), so quality is difficult to enforce even if an explicit contract contains payment

[4] I specify several possibilities for contracting so as not to limit the scope of analysis. The model is sufficiently general to allow me to analyze a range of contracting issues in agriculture.

schedules that are contingent on quality. In this case, processors have the power to renege on promised bonuses or premiums by not reporting quality truthfully. There are also other reasons for relational contracting. For example, a processor may contract with growers in order to optimize processing plant capacity which requires delivery schedule coordination with growers. In this case, successful coordination may require both parties to "perform" by exhibiting a certain degree of flexibility, adaptability, and cooperation, which are difficult-to-verify performance factors. Also, processors may want to reduce costs by exploiting scale effects or new technology, which would require growers to remain "flexible" and upgrade facilities. The point is that there are numerous reasons for relational contracts to be important in agriculture.

To be more formal, two risk-neutral parties, a principal and an agent, consider trading during periods t = 0, 1, 2,…. At each date t, the principal contracts with an agent to obtain a benefit, a_t, where a_t is drawn from a continuous distribution with a cumulative distribution function $F(\cdot \mid e)$ on the support $A = [\underline{a}, \overline{a}]$, which is conditional on the level of effort, $e_t \in E = [0, \overline{e}]$ exerted by the agent. It is also assumed that a_t is observable but not verifiable, which implies that it is not possible to write an explicit contract that conditions payments on a_t.[5] Hence, any incentive scheme that is based on a_t (e.g. promised bonus payments contingent on the level of a_t) is merely promised but cannot be enforced by a third party such as a court of law. It is assumed that $F(\cdot \mid e)$ has the monotone likelihood ratio property (MLRP) and the convexity of the distribution

[5] I do not specify what a is exactly to maintain generality. Using the previous examples, if the principal is chiefly concerned with input quality, then a might denote measured quality of the commodity which is not verifiable by a third party. If maintaining plant capacity is the principal's primary aim so that delivery schedule coordination is crucial, then a could be the degree of cooperation and flexibility exhibited by the grower to meet scheduling requirements. The key point is that a represents a measure of performance that is not verifiable by a third party.

property (CDFC), which allow us to use the first-order approach in specifying incentive-compatibility constraints (Rogerson, 1985) to deal with a moral hazard problem. The agent incurs a cost of $c(e_t \mid I)$ with assumptions of $c(0 \mid I) = 0$, $c_e(e_t \mid I) > 0$ for e >0, and $c_{ee}(e_t \mid I) \geq 0$, where $I \in \{0, I^0\}$ represents a binary-valued relationship-specific investment that is specified by the principal during the initial period (t = 0) when the relationship is established. While the principal specifies the level of I, the cost of the investment is borne by the agent. Alternatively, one can think of an investment level of $I = I^0$ as a technological requirement for producing a_t so that $c(e_t \mid I = 0) = +\infty \quad \forall e > 0$. It is assumed that the investment needs to be made once at t = 0 but does not need to be made again in subsequent periods. To maintain notational simplicity, I will henceforth suppress I in the cost function. Finally, to ensure interior solutions, it is assumed that the Inada conditions $c_e(0) = 0$ and $c_e(\overline{e}) = +\infty$ hold.

The assumption that the principal requires the agent to undertake an observable and verifiable investment, I, is consistent with stylized facts in some agricultural sectors. For example, in the livestock sector, it is often the case that, in order to initiate a contract, growers are required to make substantial investments in new production facilities (Lewin-Solomons, 2000). These facilities are often relationship-specific as they must meet the exact requirements of each integrator, and they often force growers into debt as they can cost hundreds of thousands of dollars to build. Because I is observable and verifiable and must meet the exact specifications of a processor, it is essentially a choice variable for the processor. By assuming that the principal's specialized production requirements dictate that the agent must invest in a relationship-specific technology prior to contracting, a technological constraint is essentially imposed on the design of the optimal relational contract. Moreover, such investments are the basis for some recently proposed legislation that provides farmers with the right to be "…reimbursed for damages incurred due to termination, cancellation, or failure to renew. Damages shall be based on the value of the remaining useful life of the structures, machinery or equipment involved" (Iowa Attorney General's Office, Producer Protection Act of 2000).

The principal is also assumed to decide whether or not to continue to contract with the agent at the beginning of any period *t* in the multi-period relationship. If the principal decides to continue the relationship, she offers a compensation plan that consists of a fixed payment w_t^m, a bonus schedule $b_t(\theta_t)$ contingent on the performance outcome, $\theta_t \subseteq \{e_t, a_t\} \in \Theta$, and a possible severance payment w_{t+1}^s that would be paid in the event that the relationship is terminated at the beginning of *t+1*. Note that although w_{t+1}^s is specified in the contract for period *t* it would be paid in *t+1* conditional on termination at the beginning of period *t+1*. Denote Θ as the set of all possible outcomes for θ_t. The payment scheme offered by the principal can be divided into two parts: an explicit component, based on verifiable information, and an implicit component, based on non-verifiable performance. In the model, the only verifiable information is whether the relationship continues or separates. Therefore, the explicit part consists of the fixed payment, w_t^m, that is to be paid in period *t* and the severance payment, w_{t+1}^s, to be paid in period *t*+ 1 if the relationship is terminated at the beginning of *t+ 1*. The implicit component includes any payments such as bonuses or penalties that are contingent on non-verifiable performance and is captured by the bonus schedule, $b_t(\theta_t)$, which can be either positive or negative. To motivate a negative bonus, consider a case where performance is very low. Then the agent can "compensate" the processor and restore goodwill by granting a discount for poor performance. Indeed, in many buyer-supplier relationships both within agricultural and outside of agricultural, suppliers have been known to grant price discounts when a shipment of goods has failed to meet certain quality standards. Therefore, total transfer from the principal to the agent at the end of period *t* is $w_t(\theta_t) = w_t^m + b_t(\theta_t)$. In addition, if termination occurs at the beginning of *t+1,* an additional amount w_{t+1}^s would be paid in the next period as well. However, Macleod and Malcomson (1989) and Levin (1999) show that in the models where the principal's ex post full bargaining power, asset specificity, and an exogenous shock are not incorporated, a positive severance payment cannot improve upon the set of allocations that can be implemented with self-enforcing contracts. Therefore, I assume $w_{t+1}^s = 0$ for now as there is no economic justification for private parties to include non-zero severance payments. However, $w_{t+1}^s > 0$ will be considered later when the effect of government-mandated termination damages on the efficiency and distribution of surplus from a contractual relationship is assessed, as this legislation would essentially impose a positive severance payment on the relational contract. The agent's payoff for period *t* is then $w_t(\theta_t) - c(e_t)$, the principal's payoff is $a_t - w_t(\theta_t)$, and surplus is $a_t - c(e_t)$.

Due to the non-verifiability of θ_t, it is not possible to provide incentives contingent on θ_t in a static relationship, so that productive trading must be governed by a relational contract that extends beyond a single period. Since the contingent payment, $b_t(\theta_t)$ cannot be enforced by a third party, either the principal or the agent has an incentive to renege on a contract in a one-shot relationship. However, when both parties are engaged in a repeated relationship, the promise of future payoffs can provide incentives for parties not to renege, leading to self-enforcing agreements. Bolton and Dewatripont (2005) suggest that agreements are self-enforcing when there are credible future threats (or rewards) that can induce parties to stick to the terms of the informal agreement. More formally, a relational contract is a complete plan of action that describes for every period t and every possible history up to t (i) the principal's decision to continue or terminate the relationship; (ii) the payment scheme offered by the principal in the case of continuation; (iii) the agent's decision to accept or reject the principal's offer; and (iv) the action (i.e., an effort level) the agent should take.[6]

Figure 1 illustrates the timing of the relationship in the first two periods $t = 0$ and $t = 1$. The timing of the relationship in all periods $t \geq 1$ is identical to that in $t = 1$.

[6] My definition of a relational contract is closely related to the definition given by Levin (2003). It describes a perfect public equilibrium of the repeated game.

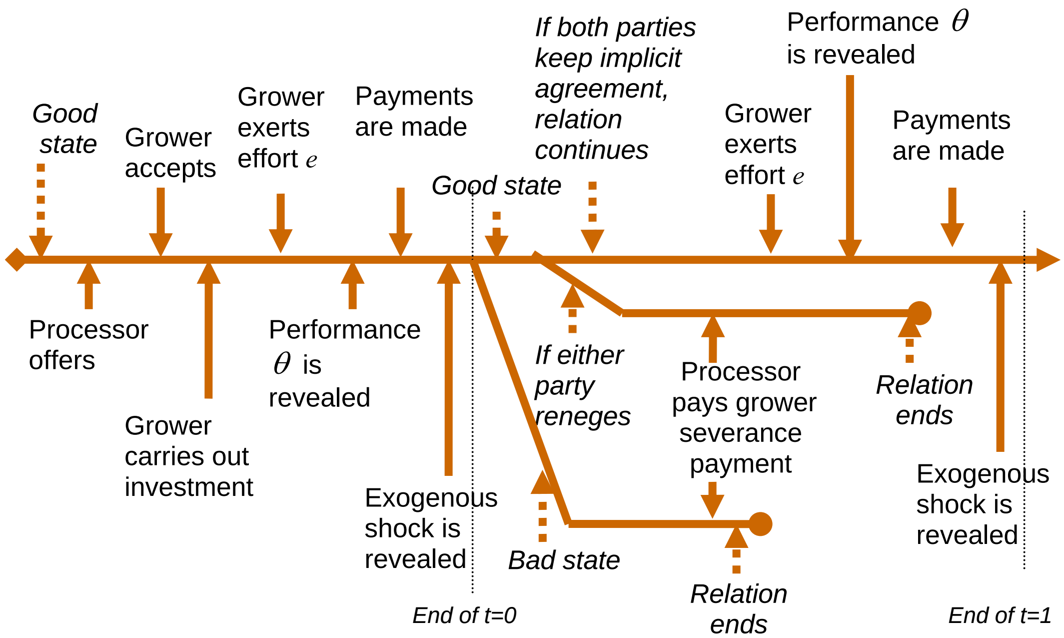

Figure 1: Timing of relational contracts.

Next, I will specify reservation payoffs for the principal and the agent in the case that no trade occurs. If a principal cannot find an agent to produce the benefit, a_t, or cannot appropriately incentivize agents, then the principal is assumed to pursue an alternative line of business and receive a fixed per-period outside payoff of $\overline{\pi}$. For example, in order to produce a high-quality consumer product, the principal may have to source input commodity with special quality characteristics. If it cannot incentivize agents to produce the required quality characteristics, then the principal may be better off sourcing inputs from the spot market and producing a generic consumer good for which it will derive profits of $\overline{\pi}$, which is called the principal's *ex ante* reservation payoff. Similarly, if the agent does not receive a contract offer or rejects an offer, the agent gets a fixed per-period outside payoff of $\overline{u}$, which is called the agent's *ex ante* reservation payoff.

It is also important to specify the *ex post* reservation payoffs, which are payoffs received by the parties if an existing relationship is terminated. It is assumed that if the principal separates from a specific agent in some period after the contract has been initiated, it can still sign a contract with another agent and earn expected per-period payoffs of $\pi_{-G}(e)$ under efficient trade.[7] $\pi_{-G}(e)$ is called the principal's *ex post* reservation payoff and is denoted by π_{-G} in order to conserve notation. The principal has an incentive to find another agent rather than exit the industry so long as $\pi_{-G} \geq \overline{\pi}$. For the agent, I denote the *ex post* reservation payoff as $\tilde{u}$ and assume that it differs from the ex ante reservation payoff, $\overline{u}$ due to the presence of the relationship-specific investment, *I*. For example, with relationship-specific investments, $\overline{u} > \tilde{u}$ stems from the fact that an agent's asset will be less worth outside the relationship than within the relationship. Finally, it is assumed that if the principal and the agent separate, the agent cannot contract with the same principal again. This assumption greatly simplifies expression of discounted expected payoffs with no loss in generality.

In any period of the repeated relationship, the traders care about their discounted expected payoff streams. In any period *t*, assuming that the principal can make an offer that is sufficiently attractive to the agent and can provide adequate incentives, the

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[7] If the processor cannot initiate efficient trade; that is, cannot provide another grower with the incentive to exert optimal effort after termination, the ex post reservation payoff is denoted by $\pi_{-G}(0)$. I assume that $\pi_{-G}(0) < \overline{\pi}$, in which case the processor will get only $\overline{\pi}$ after terminating the current grower.

discounted expected payoffs to the principal and agent, expressed as per-period averages, are:

$$(1)\quad \pi_t \equiv (1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left[(1-v_\tau)\left\{d_\tau E_{a_\tau}[a_\tau - w_\tau \mid e_\tau] + (1-d_\tau)\pi_{-G}\right\} + v_\tau \pi_{-G}\right] \text{ and}$$

$$(2)\quad u_t \equiv (1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left[(1-v_\tau)\left\{d_\tau E_{a_\tau}[w_\tau - c(e_\tau \mid I^0) \mid e_\tau] + (1-d_\tau)u^R\right\} + v_\tau \tilde{u}\right]$$

where $\delta \in [0,1)$ is a common discount factor; d_τ is 1 if the agent accepts the principal's offer and 0 otherwise; v_τ is 0 if the relationship has not been terminated prior to t and 1 otherwise; and $u^R = \bar{u}$ if $t = 0$ and $u^R = \tilde{u}$ if $t > 0$. If $t = 0$, I would have to factor in the investment I^0 made by the agent at the request of the principal. To simplify the analysis, I assume that the ex ante reservation payoff, $\bar{u}$ implicitly captures the opportunity cost of this investment.

2. 2. Self-Enforcing Stationary Contracts

The most important feature of relational contracts is that contracts must be self-enforcing to both parties. This means that each party must find it advantageous to honor the contract rather than renege on promised bonuses that are contingent on non-verifiable performance outcomes. In addition, relational contracts must specify what happens if either party reneges by not holding up her end of the bargain. Levin (2003) suggests that, since reneging should never occur in equilibrium, there is no harm in assuming that the parties terminate the relationship as this is the worse possible outcome.

He explains the conditions necessary for a relational contract to be self-enforcing in the case of $\pi_{-G} = \overline{\pi}$, $\widetilde{u} = \overline{u}$, $w^s = 0$,[8] and no relationship-specific investment requirement. His conditions are addressed, as these will be the starting point for subsequent analysis. Suppose that a contract in the initial period specifies effort e, a fixed payment w^m, a bonus schedule $b : \Theta \rightarrow R$, and, if parties do not renege on their obligations, continuation payoffs of $u(\theta)$ and $\pi(\theta)$, which are functions of the performance outcome θ.[9] If either party reneges, then the parties deviate to the static one-shot equilibrium and receive only reservation payoffs. The expected per-period payoffs from this contract are:

(3) $u \equiv (1-\delta)E_a[w^m + b(\theta) - c(e) \mid e] + \delta E_a[u(\theta) \mid e]$ and

(4) $\pi \equiv (1-\delta)E_a[a - w^m - b(\theta) \mid e] + \delta E_a[\pi(\theta) \mid e]$.

$s = u + \pi$ is expected surplus from the relationship. One can also think of (3) and (4) in terms of the discounted expected payoffs expressed in (1) and (2). If in $t = 0$, one evaluated (1) and (2) using the initial contract and assumed that $v_t = 0$ (no termination in any period t) and $d_t = 1$ (agent always accepts the contract) for $t = 0, 1, 2, \ldots$, then one would obtain π_0 and u_0, which are equivalent to π and u in (3) and (4). Moreover, the continuation payoffs $\pi(\theta)$ and $u(\theta)$ in (3) and (4) can be thought of as the period $t = 1$ discounted expected payoffs expressed as per-period averages contingent on the performance outcome, θ, of the period $t = 0$ under the assumption of $v_t = 0$ and $d_t = 1$ for $t = 1, 2, \ldots$. Therefore, u and π are value functions of expressions (1) and (2) under

[8] Macleod and Malcomson (1989) and Levin (1999) show that a positive severance payment cannot improve upon the set of allocations that can be implemented with self- enforcing contracts.
[9] These continuation payoffs can also be thought of as continuation value functions.

the assumption that the contract is never terminated in any period and that the agent will always accept an offer in every period.

Denoting the principal by "P" and the agent by "A," the contract is self-enforcing if and only if:

(i) $u \geq \bar{u}$ and $\pi \geq \bar{\pi}$ (P and A willing to initiate the contract)

(ii) $e \in \arg\max_{\tilde{e}} E_a\left[b(\theta) + \frac{\delta}{1-\delta}u(\theta) \mid \tilde{e}\right] - c(\tilde{e})$ (Incentive-compatible if *e* unobservable)

(iii) $-b(\theta) + \frac{\delta}{1-\delta}\pi(\theta) \geq \frac{\delta}{1-\delta}\bar{\pi} \quad \forall \theta \in \Theta$ (P does not renege on bonus payments)

(iv) $b(\theta) + \frac{\delta}{1-\delta}u(\theta) \geq \frac{\delta}{1-\delta}\bar{u} \quad \forall \theta \in \Theta$ (A does not renege on bonus payments).

The final condition that is required is (v) $\forall \theta \in \Theta$, the continuation payoffs $u(\theta)$ and $\pi(\theta)$ are compatible with a self-enforcing contract that will be initiated in the next period; that is, the continuation contract must also be self-enforcing. The conditions specified in (iii) and (iv) can also be called *discretionary payment constraints* as they ensure that both the principal and the agent are willing to pay promised bonuses rather than renege. For the principal, paying the bonus and continuing the relationship will earn discounted payoffs of $-b(\theta) + \frac{\delta}{1-\delta}\pi(\theta)$ that should exceed discounted payoffs of $\frac{\delta}{1-\delta}\bar{\pi}$ from reneging. A similar interpretation holds for the agent.

Before proceeding, I will define a *stationary contract*. An advantage of restricting attention to stationary contracts is that it significantly simplifies the problem of finding the optimal contract. A stationary contract is one for which, in every period, the principal offers the same payment plan and the agent acts according to the same decision rule. Levin (2003) defines a stationary contract as follows:

DEFINITION 1 *(Levin, 2003): A contract is stationary if on equilibrium path* $w_t = w^m + b(\theta_t)$ *and* $e_t = e$ *in every period t, for some* $w^m \in \mathrm{R}$, $b: \Theta \rightarrow \mathrm{R}$, *and* $e \in [0, \bar{e}]$.

Additionally, Levin's (2003) Theorem 2 makes the important point that if optimal relational contracts exist, then there are also stationary contracts that are optimal. Intuitively, in simple moral hazard models, the principal can provide incentives either through current period bonuses (punishments) or by ratcheting up (down) promised continuation payoffs. However, under the assumption of risk-neutrality, it matters little whether the principal motivates effort through bonuses (punishments) or continuation payoffs, as they are perfectly substitutable. Thus, the parties can adjust discretionary payments at the end of each period to account for variations in performance rather than change equilibrium behavior through a change in continuation payoffs. This makes it possible for the parties to enter the next period with exactly the same contract with no change in continuation equilibrium.

In this essay, I will characterize a stationary contract as a list $(w^m, w^s, b(\theta), e, \pi, u)$ where the subscript *t* is no longer necessary because the compensation plan, effort, and expected payoffs for each period are stationary across periods. In words, any stationary contract can be expressed by an explicit part (w^m, w^s), an implicit part $(b(\theta), e)$, and the expected per-period payoffs (π, u) in a concise way. While the list includes w^s as part of the contract, it is still assumed that private parties would not negotiate a contract that offers non-zero severance payments. Nonetheless, when termination damage legislation is assessed later, I will need to consider government imposed non-zero severance payments.

2. 3. Moral Hazard

In this section, the optimal relational contract with moral hazard is discussed. I maintain the assumption that the stochastic benefit, *a*, is observable by both parties but not verifiable and assume that effort, *e*, is no longer observable by the principal. In a complete contracting environment where *a* is both observable and verifiable, it is well known that, under risk neutrality, there exist contracts that can implement the first best effort level, unless a limited liability constraint exists. However, when the benefit is not verifiable, the first best level of effort may not be implementable because the requirement of self-enforcement will limit the variation in the bonus schedule, $b(\theta)$. Because $b(\theta)$ is used to provide incentives and motivate effort, limiting its range constrains incentive provision in the same way that limited liability constraints do in the complete contracting environment. To see this, note that the discretionary payment constraints, which were listed in conditions (iii) and (iv) for self-enforcement, imply that:

(5) $\frac{\delta}{1-\delta}\left(\pi-\overline{\pi}\right)\geq\sup_{\theta}b(\theta)$ and

(6) $\frac{\delta}{1-\delta}\left(u-\overline{u}\right)\geq-\inf_{\theta}b(\theta)$.

These restrictions imply that the largest discretionary payments that the parties may have to pay will be less than or equal to discounted future payoffs from continuation. These restrictions imply that, even under the best (worst) performance outcomes, discretionary payments will not be so high (low) so as to cause the parties to renege on payments. Adding (5) and (6) together yields:

(7) $$\frac{\delta}{1-\delta}\left(\pi + u - \bar{u} - \bar{\pi}\right) = \frac{\delta}{1-\delta}(s - \bar{s}) \geq \sup_{\theta} b(\theta) - \inf_{\theta} b(\theta),$$

which implies that the allowable variation in discretionary payments under self-enforcement cannot exceed discounted future gains from contracting. Because "high-powered" incentives are typically associated with large variations in performance pay, (7) acts as a constraint that limits the power of incentives, which reduces the set of *e* that can be implemented using a self-enforcing contract. The constraint (7) is formally called a *dynamic enforcement constraint* (Levin, 2003) and must be included alongside an incentive-compatibility constraint in the stationary relational contract design problem. I now let $\theta = \{a\}$ because *e* is not observable under moral hazard. Then, the discretionary payment is expressed as $b(a)$. According to Levin (2003), any effort level that generates an expected per-period surplus of *s* can be implemented with a stationary contract $\left(w^m, 0, b(a), e, u, \pi\right)$ if and only if the following conditions are met:

(8) $$e = \arg\max_{\tilde{e}} w^m + \int b(a) f(a \mid \tilde{e}) da - c(\tilde{e})$$ [10] (IC) and

(9) $$\frac{\delta}{1-\delta}\left[s - \bar{s}\right] \geq \sup b(a) - \inf b(a)$$ (DE).

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[10] I omit $\underline{a}, \bar{a}$, in $\int_{\underline{a}}^{\bar{a}} af(a \mid e) da$ for simplicity of notation from this point onwards.

Under the conditions and assumptions described above, Levin (2003) shows that the optimal relational contract that can implement any e satisfying (8) and (9) is of a "one-step" form.[11] A one-step contract compresses performance information into just two levels: "good" performance and "bad" performance. The corresponding "one-step" bonus schedule is then $b(a) = \sup_a b(a) = \inf_a b(a) + \frac{\delta}{1-\delta}(s - \overline{s})$ for all $a \geq \hat{a}$, and $b(a) = \inf_a b(a)$ for all $a < \hat{a}$, where $\hat{a}$ is the point at which the likelihood ratio $f_e(a \mid e)/f(a \mid e)$ changes from negative to positive as a function of a. In other words, this contract calls for maximal reward and punishment allowable under the (DE) constraint. The intuition is that, under risk neutrality, the strongest possible incentives should be used to motivate effort.[12]

2. 4. Ex Post Bargaining Power

One of major contributions of this essay is that it provides an analysis of how the optimal contract and the distribution of surplus are affected when the principal has ex post market or bargaining power. In addition, it is assessed how government regulation of contracts would affect efficiency and distribution when the principal possesses market power. The principal is assumed to have ex post full bargaining power if $\pi = \pi_{-G}$; that is,

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[11] See Theorem 6 and the associated proof in Levin (2003).

[12] The first-order condition of the (IC) constraint is $\int b(a) f_e(a \mid e) da = c'(e)$. Note that, for all $a \geq \hat{a}$, $f_e(a \mid e) \geq 0$, and for all $a < \hat{a}$, $f_e(a \mid e) < 0$. Furthermore, for all $e > 0, c'(e) > 0$. This implies that the one-step bonus schedule maximizes the LHS for any available variation in bonus schedule and, then, the level of effort to satisfy the first-order condition is maximized.

it is costless for the principal to terminate any specific agent because the principal can earn the same payoff through another agent. This imposes a constraint on the set of self-enforcing contracts as the principal has little incentive to commit to a long-term relationship with any specific grower. In some agricultural sub-sectors, large processors such as Tyson Foods, Gold Kist, Perdue Farmers, Pilgrim's Pride, ConAgra, etc. dominate an input market, so that there are few buyers but many growers lining up for contracts with these processors.[13] In this case, a large processor may lose little if separated from a specific grower because there is always another grower waiting to replace the departed grower. I can represent less extreme cases of bargaining power by allowing for $\pi > \pi_{-G}$ so that the principal earns some agent-specific rents.

2. 5. Exogenous Shocks

At the conclusion of each period t and prior to the beginning of $t+1$, an exogenous shock that affects productivity of contractual relationships is revealed. The inclusion of such a shock allows us to introduce non-performance-related contract termination, which occurs in agriculture and many other industries. Negative economic shocks often induce firms to lay off growers, workers, or suppliers even if these agents performed well in the past.

[13] CR4 – the total market share of the four firms with the largest market shares in a market – of Broilers was 50% in 2001. (Source: Mary Hendrickson and William Heffernan (2002), Concentration of Agricultural Markets, Department of Rural Sociology University of Missouri)

To model this, I assume a binary exogenous shock, $x = \{x_G, x_B\}$, where x_G and x_B represent, respectively, a good state and a bad state. As to the information structure of the exogenous shock, two different cases will be considered. In the first case, called symmetric information about the exogenous shock, both principal and agent are assumed to know the true probability that a bad state takes place. In the second case, called asymmetric information about the exogenous shock, it is assumed that although both parties may not know the true probability of each state, the principal can measure the probability more precisely than the agent. Later analyses will be provided for the case of symmetric information about the exogenous shock up to chapter 4 and for the case of asymmetric information about the exogenous shock in chapter 5.

In the case of symmetric information about the exogenous shock, it is assumed that that prior to the realization of the exogenous shock, the probability distribution of the exogenous shock such that $p = prob(x = x_G)$ and $1 - p = prob(x = x_B)$ is *common knowledge*. The probability distribution remains stable across periods. I will denote $\pi_{|x_B}$ and $u_{|x_B}$ as the principal's and the agent's respective payoffs under the contract conditional on bad state. The key assumption is that when x_B is realized at the end of any period, $\pi_{|x_B} + u_{|x_B}$ is less than $\overline{\pi} + \widetilde{u}$ in all future periods, so that at least one party wants to terminate the relationship.[14] Intuitively, if the bad state is realized, it becomes

[14] Since $\pi_{|x_B} + u_{|x_B}$ is less than $\overline{\pi} + \widetilde{u}$, at least one party always wants to terminate the relationship ex post after the bad state is observed. If $u_{|x_B} \geq \widetilde{u}$ ($\pi_{|x_B} \geq \overline{\pi}$), the processor (grower) wants to terminate the relationship since $\pi_{|x_B} < \overline{\pi}$ ($u_{|x_B} < \widetilde{u}$). If I assume that $\pi_{|x_B} + u_{|x_B}$ is less than $\overline{\pi} + \overline{u}$, both parties agree on termination ex ante since at least one party's participation constraint cannot be satisfied. However, if $\pi_{|x_B} + u_{|x_B}$ could be larger than $\overline{\pi} + \widetilde{u}$, both parties want to continue the relationship ex

socially efficient for the relationship to terminate, as it can no longer generate sufficient surplus in the future. Moreover, because there is no sufficient surplus, it will be impossible to reward both parties using the promise of future payoffs to sustain a self-enforcing contract. For simplicity, I assume that this condition holds between the principal and all agents, so that the principal is better off exiting the industry and earns $\overline{\pi}$ in all future periods. However, if the good state, x_G, is realized, the relationship continues as before.

Separation can also occur under the good state if the parties renege on their promises, say, because the contract is not self-enforcing. If either party reneges by withholding the discretionary payment, $b(a)$, then the relationship is terminated. However, in this case, because the bad state has not occurred, there is still sufficient surplus to be earned if the principal can find a replacement agent. It is assumed that the principal can expect to earn $\pi_{-G|x_G}(e)$ from some other agent. However, the previous agent would earn only a fixed per-period outside payoff of $\tilde{u} < \overline{u}$ due to the relationship-specific investment. Thus, once a relationship is terminated in the good state, the principal and the agent receive, respectively, $\pi_{-G|x_G}(e)$ and $\widetilde{u}$ in each period, which are called the principal's and the agent's *ex post* reservation payoffs conditional on the good state. $\pi_{-G|x_G}(e) \geq \overline{\pi}$ is assumed, so that the principal continues to contract for some benefit with some other agent rather than engage in some outside option such as

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post even in the bad state. Therefore, in order to exclude this case, I assume that $\pi_{|x_B} + u_{|x_B}$ is less than $\overline{\pi} + \widetilde{u}$.

operating on spot markets or producing an alternative line of products. For notational simplicity, I will henceforth refer to $\pi_{-G|x_G}(e)$ with the simpler $\pi_{-G|x_G}$.

With the introduction of the exogenous shock and bargaining power, some modifications to the earlier relational contract are necessary. Now, when a contract specifies effort e, a fixed payment w^m, a bonus schedule $b: A \to \mathrm{R}$, and continuation payoffs $u(a)$ and $\pi(a)$, these continuation payoffs are contingent on the good state of nature. In the bad state of nature, the relationship breaks off and the parties receive their bad state ex post reservation payoffs, $\overline{\pi}$ and $\widetilde{u}$.

The expected per-period payoffs are:

(10) $u \equiv (1-\delta)E_a[w^m + b(a) - c(e) \mid e] + p\delta E_a[u(a) \mid e] + (1-p)\delta\tilde{u}$,

(11) $\pi \equiv (1-\delta)E_a[a - w^m - b(a) \mid e] + p\delta E_a[\pi(a) \mid e] + (1-p)\delta\overline{\pi}$,

and $s = u + \pi$ is the expected per-period surplus. This contract is self-enforcing if and only if:

(i*) $u \geq \overline{u}$ and $\pi \geq \overline{\pi}$ (P and A willing to initiate the contract),

(ii*) $e \in \arg\max_{\tilde{e}} E_a\left[b(a) + p\frac{\delta}{1-\delta}u(a) \mid \tilde{e}\right] - c(\tilde{e})$ (Incentive compatibility constraint),

(iii*) $-b(a) + p\frac{\delta}{1-\delta}\pi(a) \geq p\frac{\delta}{1-\delta}\pi_{-G|x_G}, \forall a \in A$ (Discretionary payment constraint for P),

(iv*) $b(a) + p\frac{\delta}{1-\delta}u(a) \geq p\frac{\delta}{1-\delta}\widetilde{u}$, $\forall a \in A$ (Discretionary payment constraint for A),

and (v*) for all a, a pair of the continuation payoffs in good state, $u(a)$ and $\pi(a)$, corresponds to a self-enforcing contract. As before, I restrict attention to stationary contracts, as this greatly simplifies the problem of describing the optimal self-enforcing contract in the presence of the exogenous shock. Remark 1 to follow allows us to focus on stationary contracts, but I first define a stationary contract in the presence of the exogenous shock.

DEFINITION 2: *A contract is stationary if, on the equilibrium path contingent on the good state,* $w_t = w^m + b(a_t)$ *and* $e_t = e$ *in every period t, for some* $w^m \in \mathrm{R}$, $b: A \to \mathrm{R}$, *and* $e \in [0, \bar{e}]$*; and on the equilibrium path contingent on the bad state, at least one party wants to terminate the contract.*

Under this definition, the principal offers the same payment plan and the agent acts according to the same decision rule in every period in which x_G is observed. Additionally, if x_B is observed, future trading will no longer yield sufficient surplus to sustain the relational contract, so the parties break off trade and receive the bad state ex post reservation payoffs, $\bar{\pi}$ and $\tilde{u}$.

REMARK 1: *When* $\pi \geq \pi_{-G|x_G} \geq \bar{\pi} = \pi_{-G|x_B}$, $\bar{u} > \tilde{u}$, $\pi_{|x_B} + u_{|x_B} < \bar{\pi} + \tilde{u}$, *and* $x = \{x_G, x_B\}$ *with* $p = prob(x_G)$ *and* $1 - p = prob(x_B)$, *if an optimal self-enforcing contract exists, there also exists stationary contracts that are optimal.*

Proofs for all remarks and propositions are provided in the Appendix A.

CHAPTER 3

EX POST BARGAINING POWER, ASSET SPECIFICITY, AND CONTRACT STRUCTURE

In this chapter, I will examine several scenarios differentiated by the degree of ex post bargaining power possessed by the principal and the amount of asset specificity imposed on the agent via the relationship-specific investment. In each scenario, I will remark on how the structure of the relational contract is impacted, what impact this has on efficiency, and what the distributional consequences are.

3. 1. Case 1: Ex Post Full Bargaining Power and No Asset Specificity

I begin with the most extreme case where $\pi = \pi_{-G|x_G}$ and $\tilde{u} = \overline{u}$. In this case, no separation costs exist for the principal, and no asset specificity exists for the agent.

REMARK 2: *When* $\pi = \pi_{-G|x_G}$ *and* $\tilde{u} = \overline{u}$*, a self-enforcing stationary contract,* $\left(w^m, 0, b(a), e, \pi, \overline{u}\right)$*, that promises the agent only expected per-period payoff of* $u = \overline{u}$ *cannot implement any* $e > 0$.

Remark 2 makes the important point that the principal must provide the agent with a level of u that exceeds $\bar{u}$ if the principal wants the agent to exert a positive level of effort. Thus, the principal must provide the agent with efficiency wage type rents in order to motivate the agent. However, because the principal can always costlessly switch to another grower ex post, she cannot credibly promise a positive discretionary payment; i.e., the principal can always do better by reneging on the bonus and costlessly switching to another grower rather than paying the bonus when the time comes. Hence, the only credible incentive scheme is one that combines a high base pay with a negative bonus that still promises an expected payoff of $u > \bar{u}$. To see this, note that if the agent is promised $u > \bar{u}$, then his discretionary payment constraint is

$\inf_a b(a) + p\frac{\delta}{1-\delta}u \geq p\frac{\delta}{1-\delta}\bar{u}$, so that the smallest bonus possible is $-\frac{p\delta}{1-\delta}(u-\bar{u}) < 0$.

Note also from the principal's discretionary payment constraint that

$-\sup_a b(a) + p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\pi$, which implies that the largest possible bonus is zero.

Also, because the principal gets a payoff of $\pi = \pi_{-G|x_G}$ regardless of which agent she contracts with, the principal earns no relationship-specific rents from any agent. Thus, all relationship-specific rents would be paid to the agent to motivate effort. This suggests that it is not possible to separate efficiency from distribution. While Levin's (2003) Theorem 1 noted that distribution can be separated from incentives through discretionary adjustments of the fixed payment portion of the compensation scheme to achieve any desirable distribution of the total surplus across the two parties, I show here that this is no longer possible when the principal has ex post full bargaining power.

3. 2. Case 2: Ex Post Full Bargaining Power and Asset Specificity

In the second scenario, it is assumed that $\overline{u} > \widetilde{u}$ and $\pi = \pi_{-G|x_G} \geq \overline{\pi}$. The principal can costlessly switch to another agent, while the agent incurs a separation cost due to a loss in value of the relationship-specific investment. I will characterize an optimal self-enforcing stationary contract by analyzing the principal's contract design problem:

$$\text{(P1)} \quad \max_{w^m, b(a), e} \pi = \frac{1-\delta}{1-\delta p}\left\{\int \left(a - b(a)\right) f(a \mid e) da - w^m\right\} + \frac{\delta - \delta p}{1-\delta p}\overline{\pi}$$

$$\text{s.t.} \quad u = \frac{1-\delta}{1-\delta p}\left\{w^m + \int b(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p}{1-\delta p}\widetilde{u} \geq \overline{u}$$

(Participation constraint for A),

$$e = \arg\max_{\tilde{e}} w^m + \int b(a) f(a \mid \tilde{e}) da - c(\tilde{e}) \qquad \text{(IC)},$$

$$-\sup_a b(a) + p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\overline{\pi} \quad \text{(Discretionary payment constraint for P)},$$

$$\inf_a b(a) + p\frac{\delta}{1-\delta}u \geq p\frac{\delta}{1-\delta}\widetilde{u} \quad \text{(Discretionary payment constraint for A)}.$$

While the above problem looks like a static optimization problem, the stationary nature of the relational contract allows us to write the dynamic optimization problem as above.

Before solving (P1), I will first analyze some of the constraints of the problem to shed light on the structure of the relational contract and associated distributional and efficiency implications when there is asset specificity and the principal has ex post full bargaining power. Combining the discretionary payment constraints for both parties implies the following dynamic enforcement (DE) constraint,

(12) $\frac{p\delta}{1-\delta}(u-\tilde{u}) \geq \sup_a b(a) - \inf_a b(a)$.

Note that the principal can relax the (DE) constraint by promising the agent greater u, which would increase allowable discretionary payment variation under the self-enforcing contract. This increased variation implies that higher-powered incentives can be provided, which increases the set of implementable effort levels. However, it is costly for the principal to increase u as increased transfers to the agent means a reduction in π. Therefore, the principal must weight the efficiency gains from increasing u (possible increase in effort and hence greater profits) against the cost of making costly transfers to the agent. Moreover, the (DE) constraint can be relaxed if p increases. Thus, increased likelihood of continuation would also relax the (DE) constraint and lead to a possible increase in efficiency. The constraints of (P1) also allow us to derive the first major result: non-zero severance payments are not needed to enhance efficiency even when the principal has ex post full bargaining power.

PROPOSITION 1: *When* $\pi = \pi_{-G|x_G}$ *and* $\bar{u} > \tilde{u}$*, if there is a self-enforcing stationary contract* $\left(w^m, w^s, b(a), e, \pi, u\right)$*, where* $w^s > 0$*, there exists a self-enforcing stationary contract that can implement the same effort and give the both parties the same expected per-period payoffs with zero severance payments.*

The above proposition is important as it suggests that government-imposed termination damages, which are essentially externally imposed severance payments, would not improve efficiency. I will discuss this point in greater detail in the subsequent section on regulation.

With regard to the specific contract structure, the only credible self-enforcing contract involves a high fixed payment combined with a deduction or a negative bonus payment.

REMARK 3: *When* $\pi = \pi_{-G|x_G}$ *and* $\overline{u} \geq \tilde{u}$, *if there is a self-enforcing stationary contract* $\left(w^m, 0, b(a), e, \pi, u\right)$, *then* $\sup_a b(a)$ *cannot be positive and* $\inf_a b(a)$ *must be negative and satisfy* $\inf_a b(a) \geq -\frac{p\delta}{1-\delta}(u - \widetilde{u})$.

Remark 3 combined with the discussion following Remark 2 suggests that discretionary adjustments in pay tend to be deducts rather than bonuses. Yet, in most real world agricultural contracts, it is frequently the case that incentives are based on both bonuses and deducts. I offer two possible explanations. First, in relational contracting settings where performance is not verifiable, it is not uncommon for suppliers or growers to offer discretionary discounts, which may not be part of the formal agreement, to buyers when performance is unsatisfactory. [15] Even if price discounts are not made, suppliers may take other types of costly actions to correct bad performance. For example, in the California processing tomato industry, when a delivery of tomatoes falls below reject standards, a processor may either accept the delivery at a discounted price or the grower

[15] As for tomato contracts, official USDA standards for US#1 tomatoes allow a 1/2 inch radial crack at the stem end; any cracking will result in a discount in the product price. (Source : Nebraska Cooperative Extension NF97-353, http://ianrpubs.unl.edu/horticulture/nf353.htm)

may have to replenish the shipment by replacing bad tomatoes with good tomatoes. Second, one should bear in mind that the assumption of full market power may be too stringent an assumption, because even if large integrators or processors hold explicit monopsony positions over growers, growers may still earn reputation or information rents that provide them with some bargaining power. When the principal does not have full bargaining power, then discretionary payments may be both positive and negative.

I will now explicitly solve (P1) to obtain the optimal contract. (P1) is converted into the following program:

(P2) $\max_{u,e,b(a)} \pi = \frac{1-\delta}{1-\delta p}\left\{\int af(a\,|\,e)da - c(e)\right\} + \frac{\delta-\delta p}{1-\delta p}\bar{\pi} - u + \frac{\delta-\delta p}{1-\delta p}\tilde{u}$

s.t. (i) $u - \bar{u} \geq 0$,

(ii) $\int b(a) f_e(a\,|\,e)da - c_e(e) = 0$, and

(iii) $-\frac{p\delta}{1-\delta}(u-\tilde{u}) \leq b(a) \leq 0$ for all a.

$u = \frac{1-\delta}{1-\delta p}\left\{w^m + \int b(a) f(a\,|\,e)da - c(e)\right\} + \frac{\delta-\delta p}{1-\delta p}\tilde{u}$ in (P1) can be expressed as:

(13) $w^m = \frac{1-\delta p}{1-\delta}\left\{u - \frac{\delta-\delta p}{1-\delta p}\tilde{u}\right\} - \int b(a) f(a\,|\,e)da + c(e)$.

Equation (13) can be substituted into the objective function of (P1) to produce the objective function of (P2). Now the principal is optimizing over *u, e,* and $b(a)$ rather than w^m, *e,* and $b(a)$ in the original (P1). This change of variables makes the optimization problem more tractable and allows the agent's participation constraint of (P1) to be simplified to $u - \bar{u} \geq 0$. The incentive-compatibility constraint of (P1) can be replaced with $\int b(a) f_e(a \mid e) da - c_e(e) = 0$ under CDFC and MRLP. The discretionary payment constraints for P and A in (P1) jointly imply constraint (iii) in (P2), which is called the *double-sided boundary constraint* for $b(a)$. Once I solve (P2), the fixed payment w^m can be recovered by substituting the solutions to (P2) into (13). Finally, if π evaluated at a solution to (P2) is equal to or larger than $\overline{\pi}$, then there exists an optimal self-enforcing stationary contract. To ensure interior solutions, I assume that the Inada conditions $c_e(0) = 0$ and $c_e(\overline{e}) = +\infty$ hold. The following proposition characterizes an optimal self-enforcing stationary contract that can be derived from solving (P2).

PROPOSITION 2: *When* $\pi = \pi_{-G|x_G}$ *and* $\overline{u} > \widetilde{u}$, *if there exists an optimal self-enforcing stationary contract, then it takes one of the following three forms:*

i) the contract promises a payoff of $u > \overline{u}$, *specifies effort of* $e < e^{FB}$, *and includes a one-step bonus schedule such that* $b(a) = 0$ *for all* $a \geq \hat{a}$ *and* $b(a) = -\frac{p\delta}{1-\delta}(u - \widetilde{u})$ *for all* $a < \hat{a}$,

ii) the contract promises a payoff of $u = \overline{u}$, *specifies effort of* $e < e^{FB}$, *and includes a one-step bonus schedule such that* $b(a) = 0$ *for all* $a \geq \hat{a}$ *and* $b(a) = -\frac{p\delta}{1-\delta}(\overline{u} - \widetilde{u})$ *for all* $a < \hat{a}$, *and*

iii) the contract promises a payoff of $u = \overline{u}$, *specifies first best effort* $e = e^{FB}$, *and includes some monotone bonus schedule satisfying the incentive-compatibility constraint,* $\int b(a) f_e(a \mid e^{FB}) da - c_e(e^{FB}) = 0$, *and the constraint,* $-\frac{p\delta}{1-\delta}(\overline{u} - \widetilde{u}) \leq b(a) \leq 0 \ \ \forall a \in A$.

In addition, if $\frac{c_e(e^{FB})}{F_e(\hat{a} \mid e^{FB})} \geq -\frac{p\delta}{1-\delta}(\overline{u}-\widetilde{u})$*, the bonus schedule can be "one-step" such that* $b(a) = 0$ *for all* $a \geq \hat{a}$ *and* $b(a) = \frac{c_e(e^{FB})}{F_e(\hat{a} \mid e^{FB})}$ *for* $a < \hat{a}$ *where* $\hat{a}$ *is such that* $f_e(\hat{a} \mid e)/f(\hat{a} \mid e) = 0$.

This proposition outlines all possible forms of the optimal self-enforcing stationary contract, where each case depends on exogenous parameters, p, δ, $\widetilde{u}$, and $\overline{u}$. Parts (i) and (ii) state that when the principal does not find it profit-maximizing to implement the first best effort level, the optimal contract will be of a "one-step" form where performance is compressed into just two levels, "good" and "bad." Parts (i) and (ii) are distinguished from each other by the amount of rents promised to the agent, which in turn depends on exogenous parameters. Part (iii) states that when it is optimal for the principal to implement the first best effort level, then any monotone bonus schedule (not necessarily one-step) that satisfies the necessary constraints can be part of an optimal contract. For example, if $\frac{p\delta}{1-\delta}(\overline{u}-\widetilde{u}) \geq \overline{a} - \underline{a}$, a bonus schedule, $b(a) = a - \overline{a}$, can implement e^{FB}, since substituting such a bonus schedule into $\int b(a) f_e(a \mid e) da - c_e(e) = 0$ yields $\int a f_e(a \mid e) da - c_e(e) = 0$, which is the first order condition for the social surplus function. Note that part (iii) does not rule out one-step bonus schedules so long as they satisfy some specific conditions.

In summary, even if the principal has ex post full bargaining power, there is asset specificity, and there is an exogenous shock, Levin's "one-step" bonus schedule is still optimal for implementing $e < e^{FB}$. However, the optimal bonus schedule only includes non-positive discretionary payments which depend on the relationship between the expected per-period payoff, u, and the reservation payoffs, $\bar{u}$ and $\tilde{u}$, making it impossible to separate efficiency from distribution.

CHAPTER 4

THE IMPACT OF GOVERNMENT REGULATIONS

In this chapter, I analyze the effect of government regulations on relational contracting. My focus will be on the distributional and efficiency consequences of regulations. I will begin by examining government-mandated breach damages that compensate growers for "…the value of the remaining useful life of the structures, machinery or equipment involved…" when contractual relationships are terminated without cause. Termination without cause may occur when a grower has performed up to expectations but is laid off anyways, which is most likely to occur when there is a negative economic shock. The relational contracting model of this essay allows us to integrate these types of termination into analysis as the model includes a negative exogenous shock, x_B, that can undermine a relationship even when both parties do not renege. These sorts of regulations have been proposed in the Producer Protection Act of 2000, as well as by various individual state legislatures. One can interpret the "value of the remaining useful life" to mean the additional amount of profit that the grower could have earned had the grower not been terminated. In this case, damages would be calculated to be the difference between payoffs that can be earned with the current processor and payoffs from the next best opportunity ex post. These damages would be analogous to severance payments of the size $w^s = \frac{u - \tilde{u}}{1-\delta}$, which would be similar to *expectation damages* in the legal literature. It is also possible that $w^s = \frac{\overline{u} - \tilde{u}}{1-\delta}$ which would be akin to *reliance damages* that make the grower indifferent between breach with damages and no contract. I can, however, make a general statement about the impact of damages (severance payments) without specifying the size of these payments.

PROPOSITION 3: *When* $\pi = \pi_{-G|x_G}$ *and* $\overline{u} > \tilde{u}$, *if there exists a self-enforcing stationary contract* $(w^m, 0, b(a), e, \pi, u)$, *then there exists a self-enforcing stationary contract* $(w^m - \delta w^s, w^s, b(a) + \delta p w^s, e, \pi, u)$ *for any positive severance payment* w^s *imposed by regulation.*

This result is surprising as it suggests that damages, whatever the size is, would have no impact on efficiency even when the processor has ex post full bargaining power and imposes asset specificity on the agent. Thus, processors would be able to design effective incentives that deliver the same effort level and expected per-period payoffs only by reconstructing the fixed payment and bonus schedule even if termination damages were made into law. Severance payments, however, do increase (decrease) the payoff that the grower (processor) can earn after the relationship is terminated contingent on bad state. This implies that ex post payoffs for the grower and processor contingent on termination are $w^s + \frac{1}{1-\delta}\tilde{u}$ and $-w^s + \frac{1}{1-\delta}\overline{\pi}$, respectively. However, a processor with rational expectations would foresee that it may have to pay damages in the future and would therefore factor expected future liabilities into its offer to the grower. Thus, if the processor promises the grower an expected payoff of $w^m + \int b(a) f(a \mid e) da - c(e)$ conditional on continuation when there is no law, then this payoff would decrease by $(1-p)\delta w^s$ if the law were passed. Consequently, regulation would reduce the grower's expected payoff *conditional* on continuation but would increase the grower's payoff in the event of termination. Given that termination damages are a tool with which policy-makers can redistribute rents across states of nature without creating contracting distortions, it is a rather effective means of ensuring that growers never realize extremely low payoffs in any state of nature. However, since both the principal and the agent are risk-neutral and termination damages do not change their expected per-period payoffs, they should not care about the redistribution of rents across states of nature.

Then, a possible question is: when does the regulation of termination damages have any economic justification? When both parties are risk-neutral, if policy-makers want to maximize expected surplus, they also will be indifferent between regulation and no regulation. On the other hand, suppose that the policy-makers' welfare function is Rawlsian or maximin given by $W = \min\{\min\{\pi_{|x_G}, u_{|x_G}\}, \min\{\pi_{|x_B}, u_{|x_B}\}\}$, where $\pi_{|x_G}$ and $u_{|x_G}$ are the expected payoffs that the principal and the agent earn for each period in the good state, and $\pi_{|x_B}$ and $u_{|x_B}$ in bad state.[16] Such policy-makers will choose the policy that maximizes the minimum among the principal's and the agent's payoffs contingent on each state of nature. Before termination damages are imposed, $\pi_{|x_B}$ is equal to $\overline{\pi}$ and $u_{|x_B}$

[16] This welfare function is constructed by using the general Rawlsian or maximin welfare function. For the details, refer to Myles (1995).

is equal to $\tilde{u}$ as defined before. In an optimal stationary self-enforcing contract, $u_{|x_G}$ is greater than or equal to $\bar{u}$ and $\pi_{|x_G}$ is greater than or equal to $\bar{\pi}$. Then, the value of the Rawlsian or maximin welfare function is $W = \tilde{u}$ if $\bar{\pi} \geq \tilde{u}$ or $W = \bar{\pi}$ if $\bar{\pi} < \tilde{u}$.

When termination damages are regulated, the principal pays w^s to the agent in the period when bad state is realized. Hence, the agent's per-period payoff in the bad state increases by $(1-\delta)w^s$. On the other hand, if the principal promises to agent the expected payoff of $u_{|x_G}$ for each period in the good state under no termination damages, this payoff decreases by $(1-p)\delta w^s$ when the regulation is passed. Therefore, if reliance damages of $w^s = \dfrac{\bar{u}-\tilde{u}}{1-\delta}$ are required, the welfare function is

$$W_D = \min\left\{\min\{\pi_{|x_G} + \frac{\delta(1-p)(\bar{u}-\tilde{u})}{1-\delta}, u_{|x_G} - \frac{\delta(1-p)(\bar{u}-\tilde{u})}{1-\delta}\}, \min\{\pi_{|x_B} - (\bar{u}-\tilde{u}), u_{|x_B} + (\bar{u}-\tilde{u})\}\right\}.$$

For example, if $\bar{\pi}$ is greater than $\bar{u}$, then

$$W_D = \min\left\{\min\{\pi_{|x_G} + \frac{\delta(1-p)(\bar{u}-\tilde{u})}{1-\delta}, u_{|x_G} - \frac{\delta(1-p)(\bar{u}-\tilde{u})}{1-\delta}\}, \min\{\bar{\pi} - (\bar{u}-\tilde{u}), \bar{u}\}\right\},$$ which

implies that $W_D = \bar{u}$ if $\bar{\pi} \geq \bar{u} + (\bar{u}-\tilde{u})$ or $W_D = (\bar{\pi}-\bar{u}) + \tilde{u}$ if $\bar{\pi} < \bar{u} + (\bar{u}-\tilde{u})$. Since $\bar{\pi} >$ $\bar{u}$ implies $\bar{\pi} > \tilde{u}$, it is obtained that $W = \tilde{u}$. Thus, W_D is greater than $W = \tilde{u}$, which implies that if policy-makers have the above Rawlsian or maximin welfare function, they may choose to impose termination damages in order to maximize social welfare. This example shows that the regulation of termination damages can be thought to improve social welfare depending on the policy-makers' welfare function.

CHAPTER 5

EXTENSION: ASYMMETRIC INFORMATION ON AN EXOGENOUS SHOCK

Up to the previous chapter, it is supposed that both parties have common knowledge of the probability distribution of the exogenous shock. This case is called symmetric information about the exogenous shock. In this chapter, I investigate optimal relational contracts in the case of asymmetric information about the exogenous shock.

The principal is assumed to have a larger information set, Ω_P, that is used to measure the probability distribution of the exogenous shock than the agent's information set, Ω_A ($\Omega_P \supset \Omega_A$). This assumption implies that the principal knows the agent's information set is Ω_A, but the agent does not know that the principal's information set is Ω_P, which means that the principal knows that the agent's (subjective) probability is p_A and the agent believes that the principal's (subjective) probability also is p_A.

This assumption is reasonable since integrators or processors in the livestock (e.g. broiler) sector are larger corporations than individual growers in that they vertically integrate production, processing, and marketing. (Leegomonchai, 2003).[17] On the other hand, growers tend to be smaller, less sophisticated operations. Therefore, processors

[17] Top 10 broiler integrators' market share was 71.32% in 2002. (Source: WATT PoultryUSA (2003); recited from Leegomonchai (2003))

may conduct more extensive market analysis than growers. Then, it is natural to assume that the principal's (subjective) probability of the good state denoted by $p_P = p(\Omega_P)$ is closer to the true probability, *p,* than is the agent's (subjective) probability denoted by $p_A = p(\Omega_A)$. That is, $|p_P - p| < |p_A - p|$ is assumed. Moreover, it is assumed that $p_P < p_A$. If the agent is more pessimistic than the principal ($p_P \geq p_A$), the principal is willing to reveal the principal's own information in order to increase the principal's own expected per-period profit. One can notice from the (DE) constraint of (12) that as *p* increases, the allowable variation in bonus schedule increases, resulting in increases in optimal effort and the principal's expected benefit. Therefore, only the case of $p_P < p_A$ is interesting to analyze.

In a different way, one can consider the following case. When Ω_A denotes the principal's information set that the agent believes and Ω_P denote the principal's true information set, the principal knows that $\Omega_P \supset \Omega_A$. This case also implies that the principal knows that the agent's (subjective) probability is p_A and the agent believes that the principal's (subjective) probability also is p_A. In summary, the two important points are, first, that that agent is more optimistic about the probability of the good state than is the principal and, second, that the principal knows this fact but the agent does not know.

I now characterize contracts under asymmetric information of an exogenous shock and show differences between these and the optimal self-enforcing stationary contracts under symmetric information about the exogenous shock. To highlight differences, it is supposed that under symmetric information about the exogenous shock, an optimal self-enforcing stationary contract takes the second form of proposition 2: the agent's expected per-period payoff is $u_S = \overline{u}$, the optimal effort is $e_S < e^{FB}$, and the bonus schedule is one-step such that $b(a) = 0$ for all $a \geq \hat{a}$ and $b(a) = -\frac{p\delta}{1-\delta}(\overline{u} - \widetilde{u})$ for all $a < \hat{a}$. The subscript *S* implies symmetric information about the exogenous shock. When an optimal self-enforcing stationary contract takes the other forms of proposition 2, the main results that will be discussed in this chapter do not change.

Under asymmetric information about the exogenous shock, the principal's contract design problem is:

$$\text{(P3)} \quad \max_{w^m, b(a), e} \pi = \frac{1-\delta}{1-\delta p_P}\left\{\int \left(a - b(a)\right) f(a \mid e) da - w^m\right\} + \frac{\delta - \delta p_P}{1-\delta p_P}\overline{\pi}$$

$$\text{s.t. } u = \frac{1-\delta}{1-\delta p_A}\left\{w^m + \int b(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p_A}{1-\delta p_A}\widetilde{u} \geq \overline{u}$$

(Participation constraint for A),

$$e = \arg\max_{\widetilde{e}} \int b(a) f(a \mid \widetilde{e}) da - c(\widetilde{e}) \qquad \text{(IC)},$$

$$-\sup_a b(a) + p_A \frac{\delta}{1-\delta}\pi \geq p_A \frac{\delta}{1-\delta}\overline{\pi} \quad \text{(Discretionary payment constraint for P)},$$

$$\inf_a b(a) + p_A \frac{\delta}{1-\delta} u \geq p_A \frac{\delta}{1-\delta}\widetilde{u} \quad \text{(Discretionary payment constraint for A)}.$$

Compared with (P1), *p* in the constraints of (P1) is replaced with p_A and *p* in the objective function of (P1) is replaced with p_P in (P3). The agent's participation constraint and the discretionary payment constraints for A and P are ones that the agent recognizes but are not true ones. This causes an increase in efficiency and results in the agent earning less than the ex ante reservation payoff of $\overline{u}$ under asymmetric information about the exogenous shock. The principal considers the discretionary payment constraint for P that the agent recognizes rather than the true discretionary payment constraint for P, since it is important to the principal that the agent believes that the principal will not default on bonus payments. Since the agent believes that the principal's (subjective) probability is also p_A, the agent considers p_A in the discretionary payment constraint for P. On the other hand, the principal's true discretionary payment constraint has p_P instead of p_A. However, this discrepancy does not matter since both the true discretionary payment constraint for P and the discretionary payment constraint for P that the agent recognizes can be simplified to $-\sup_a b(a) \geq 0$. The (IC) constraint (P1) is not affected since it does not include *p*.

I will consider as a special case of asymmetric information about the exogenous shock that the principal knows the true probability distribution of the exogenous shock but the agent believes that the probability of good state is one so there is no chance of bad state (i.e. $p = p_P < p_A = 1$).[18] In a different way, one can think that while the principal knows the existence of an exogenous shock and the probability distribution of it, the agent do not know the existence itself of this shock. However, the formal proofs of following propositions are done for a general case such as $|p_P - p| < |p_A - p|$ and $p_P < p_A$.

Then, the agent's participation constraint in (P3) simplifies to:

(14) $u = w^m + \int b(a) f(a \mid e) da - c(e) \geq \bar{u}$.

[18] As long as $|p_P - p| < |p_A - p|$ and $p_P < p_A$ are satisfied, the qualitative results are the same.

Since the agent believes that the good state continues forever and the principal knows this, the profit-maximizing (or selfish) principal does not consider the agent's ex-post reservation payoff of $\tilde{u}$ in her contract design problem. The discretionary payment constraint for A becomes:

(15) $\inf_a b(a) + \frac{\delta}{1-\delta} u \geq \frac{\delta}{1-\delta} \tilde{u}$.

The principal actually has the same discretionary payment constraint for P as that in (P1) but the discretionary payment constraint for P that the agent recognizes is the following:

(16) $-\sup_a b(a) + \frac{\delta}{1-\delta} \pi \geq \frac{\delta}{1-\delta} \pi$.

Therefore, the principal considers (16) in (P3).

Now, I address characteristics of optimal contracts under asymmetric information on an exogenous shock. Since it is assumed that the participation constraint for A is binding in an optimal contract obtained in (P1), this constraint is also binding in any optimal contract obtained in (P3). That is, the principal does not have to give the agent any rents (i.e., $u = \bar{u}$) in any optimal contract in (P3) since the principal can motivate the agent by using only more variation of a bonus schedule in (P3) than in (P1) due to $p_A = 1 > p$. Combining (15) and (16) and substituting $u = \bar{u}$ yields the (DE_{AS}) constraint:

(17) $\frac{\delta}{1-\delta}(\bar{u} - \tilde{u}) \geq \sup_a b(a) - \inf_a b(a)$.

The subscript *AS* implies asymmetric information about the exogenous shock. Because $p_A = 1 > p$, the restriction on the bonus schedule in the (DE_{AS}) constraint is relaxed compared with the (DE) constraint under symmetric information about the exogenous shock, which may lead to an increase in efficiency. That is, more variation in the bonus schedule can be employed and, hence, higher-powered incentives can be provided in order to induce effort, e_{AS}, that is greater than e_S. The subscript *AS* implies asymmetric information about the exogenous shock. The following proposition summarizes my findings.

PROPOSITION 4: *If, in the optimal contract under symmetric information about the exogenous shock, the optimal effort e_S is less than e^{FB} and u_S is equal to $\bar{u}$, the optimal effort e_{AS} is greater than e_S in the optimal contract under asymmetric information about the exogenous shock.*

It is straightforward that when e_S is equal to e^{FB} and u_S is equal to $\bar{u}$ in an optimal contract under symmetric information about the exogenous shock, e_{AS} is also equal to e^{FB} in an optimal contract under asymmetric information about the exogenous shock. That is, when the (DE) constraint does not bind for *p*, the (DE_{AS}) constraint also does not bind for $p_A > p$, since the restriction on a bonus schedule in the (DE_{AS}) constraint is relaxed compared with the (DE) constraint. Therefore, e_{AS} is equal to e^{FB}.

The agent's binding participation constraint in optimal contracts from (P3) implies that the agent's expected per-period payoff, $u_F = w^m + \int b(a) f(a \mid e) da - c(e)$, which the agent recognizes in an optimal contract under asymmetric information about the exogenous shock, is equal to $\bar{u}$. The subscript *F* implies that the agent's recognition is false. However, the agent's true expected per-period payoff, u_{AS}, is less than $u_F = \bar{u}$

because u_{AS} is the weighted sum of $u_F = \bar{u}$ and $\tilde{u} < \bar{u}$ (i.e.,

$u_{AS} = \frac{1-\delta}{1-\delta p} u_F + \frac{\delta - \delta p}{1-\delta p} \tilde{u} < u_F = \bar{u}$). The following proposition summarizes the above finding. In fact, this proposition can be applied for $e_S = e^{FB}$.

PROPOSTION 5: *When in the optimal contract under symmetric information about the exogenous shock* u_S *is equal to* $\bar{u}$*, the agent's true expected per-period payoff* u_{AS} *is less than the agent's ex-ante reservation payoff* $\bar{u}$ *in the optimal contract under asymmetric information about the exogenous shock.*

The following corollary states as the result of propositions 4 and 5, the principal's expected per-period payoff increases.

COROLLARY 1: *When in the optimal contract under symmetric information about the exogenous shock* u_S *is equal to* $\bar{u}$*, the principal's expected per-period payoff under asymmetric information about the exogenous shock,* π_{AS} *is greater than the principal's expected per-period payoff under symmetric information about the exogenous shock,* π_S*, because of propositions 4 and 5.*

Any optimal contract from (P3) is at least as efficient as an optimal contract from (P1) because $e_{AS} \geq e_S$. However, since π_{AS} is greater than π_S and u_{AS} is less than $u_S = \bar{u}$, asymmetric information about exogenous shock results in a distribution of surplus that is beneficial to the principal and harmful to the agent. This implies that while the principal may increase efficiency of a contractual relationship by using her better information about the exogenous shock, such an increase in efficiency cannot be Pareto-efficient since the agent is worse off. More importantly, any optimal contract from (P3) is actually not self-enforcing since the agent's true expected per-period payoff u_{AS} is less than $\bar{u}$, so the agent's participation constraint is actually not satisfied. The agent merely believes that it is self-enforcing (i.e., $u_F = \bar{u}$) in the case of asymmetric information on an exogenous shock. Hence, I do not label any optimal contract from (P3) as a *self-enforcing* contract.

The next question is whether termination damages can mitigate the distortionary effect of asymmetric information about the exogenous shock on the distribution of surplus. Since it is assumed that the relationship-specific investment, *I* (e.g. building factory and installing specific equipments), is verifiable, government regulation such as termination damages can be made based on *I*. I consider the case that in an optimal contract without termination damages, u_F is equal to $\bar{u}$, e_{AS} is less than e^{FB}, and the bonus schedule is one-step: $b(a) = 0$ for all $a \geq \hat{a}$ and $b(a) = -\frac{\delta}{1-\delta}(\bar{u} - \tilde{u})$ for all $a < \hat{a}$. Suppose that reliance damages, $D = \frac{\bar{u} - \tilde{u}}{1-\delta}$, are imposed on the principal whenever the relationship is separated. Then, in the principal's contract design problem under such termination damages, the agent's participation constraint is the same as (14), since the agent still does not know about the possibility of termination due to a bad state.

(IC) does not change. The discretionary payment constraints for P and A that the agent recognizes are:

(18) $-\sup_a b(a)+\frac{\delta}{1-\delta}\pi \geq \frac{\delta}{1-\delta}\pi-\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$ and

(19) $\inf_a b(a)+\frac{\delta}{1-\delta}u \geq \frac{\delta}{1-\delta}\widetilde{u}+\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$.

As shown in proposition 3, termination damages do not change the agent's expected per-period payoff and optimal effort level. The termination damages of D reduce the fixed payment by $\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$ and increase the bonus schedule by $\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$, which becomes $b(a)=0$ for all $a<\hat{a}$ and $b(a)=\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$ for all $a \geq \hat{a}$. The agent believes that a contract in which the bonus schedule and the fixed payment are adjusted like the above is self-enforcing. For this, when (18) and (19) are added together, the second terms of the right hand sides cancel. Then, the (DE_{AS}) constraint is equivalent to (17) since the agent's participation constraint is binding. Since the termination damages of D do not affect the (DE_{AS}) constraint that the agent recognizes, the same effort e_{AS} can be implemented. Since the bonus payments are either zero or positive, the agent does not have any incentive to refuse such nonnegative bonus payments, so (19) is always satisfied for all $b(a) \geq 0$. The agent also believes that the principal does not have any incentive to refuse paying the nonnegative bonus payment to the agent, since (18) is always satisfied for $0 \leq b(a) \leq \frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$. Therefore, the agent believes that a contract where a compensation plan is adjusted like the above is self-enforcing.

However, I need to check whether the principal actually does not have any incentive to default on bonus payments. The true discretionary payment constraint for P is:

$$(20)\quad -\sup_a b(a) + p\frac{\delta}{1-\delta}\pi \geq p\left\{\frac{\delta}{1-\delta}\pi - \frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})\right\}.$$

This simplifies to $\sup_a b(a) \leq p\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$. The bonus $b(a) = \frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$ for all $a \geq \hat{a}$ cannot satisfy (20) because $p < 1$. Since $\sup_a b(a) = \frac{\delta}{1-\delta}(\overline{u}-\widetilde{u}) > p\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})$, the principal can get the benefit of $\frac{\delta(1-p)}{1-\delta}(\overline{u}-\widetilde{u})$ by paying the termination damages of D instead of paying the promised bonus payment. This implies that whenever a is greater than or equal to $\hat{a}$ in any period, the principal will not pay the promised bonus payment and, instead, will terminate the relationship at the beginning of the next period. Although the agent believes that paying the promised bonus payment will be self-enforcing, it is not to the principal. Therefore, the agent's true expected per-period payoff is:

$$(21)\quad \begin{aligned} u_{AS.D} &= \frac{1-\delta}{1-\delta pF(\hat{a})}\left\{w^m + \int b(a)f(a\mid e)da - c(e)\right\} + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}(\widetilde{u}+\overline{u}-\widetilde{u}) \\ &= \frac{1-\delta}{1-\delta pF(\hat{a})}\left(w^m - c(e)\right) + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}\overline{u}. \end{aligned}$$

From the binding participation constraint of the agent and the above bonus schedule, the following fixed payment can be obtained.

$$(22)\quad w^m = \overline{u} + c(e) - \left(1-F(\hat{a})\right)\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u}).$$

Substituting (22) into (21) yields the following agent's true expected per-period payoff, $u_{AS.D}$, under asymmetric information about the exogenous shock and the termination damages of *D*:

(23) $$u_{AS.D} = \frac{1-\delta}{1-\delta pF(\hat{a})}\left(\bar{u} - (1-F(\hat{a}))\frac{\delta}{1-\delta}(\bar{u}-\tilde{u})\right) + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}\bar{u}.$$

If $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) \geq 1$, $u_{AS.D}$ is greater than or equal to u_{AS}, since $u_{AS.D} - u_{AS} = \left[\frac{\delta(1-p)}{1-\delta p} - \frac{\delta(1-F(\hat{a}))}{1-\delta pF(\hat{a})}\right](\bar{u}-\tilde{u})$. That is, the agent is better off under the termination damages. However, $u_{AS.D}$ is still less than $\bar{u}$, since $u_{AS.D}$ is the weighted average of $\bar{u}$ and $\bar{u} - (1-F(\hat{a}))\frac{\delta}{1-\delta}(\bar{u}-\tilde{u})$, which is less than $\bar{u}$. On the other hand, if $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) < 1$, the termination damages decrease the agent's true expected per-period payoff below u_{AS}, which affects the distribution of surplus even more. Note that $\frac{1-\delta pF(\hat{a})}{1-\delta p}$ is always greater than one. Then, when the true probability of the good state, *p,* is large enough compared to the probability of the bad state, $F(\hat{a})$, the likelihood is high that termination damages affect the agent's expected per-period payoff negatively.

The effect of termination damages on the distribution of surplus varies drastically depending on the values of $p, \delta,$ and $F(\hat{a})$. The following proposition characterizes my findings and implies that government regulation of contracts via termination damages either mitigates or aggravates the distortion of distribution of surplus that is caused by asymmetric information about the exogenous shock.

PROPOSITION 6: *When* $u_F = \overline{u}$ *and* $e_{AS} < e^{FB}$ *in an optimal contract under asymmetric information about the exogenous shock and no termination damages, termination damages do not affect the level of effort but do affect the distribution of surplus. If* $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) < 1$, *the agent is worse off under termination damages. If* $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) \geq 1$, *the agent is at least better off under termination damages, but the agent's expected per-period payoff is still less than* $\overline{u}$.

CHAPTER 6

CONCLUSION AND IMPLICATION

This essay analyzed optimal relational contracts under the assumptions that agents (e.g. growers) must make relationship-specific investments prior to contracting and that principals (e.g. processors) have ex post full bargaining power due to monopsony power. I also analyzed the potential impact of government-imposed termination damages on incentive design, efficiency, and the distribution of surplus between processors and growers. Primary findings are that optimal relational contracts in the presence of the processor's ex post full bargaining power will result in contracts that offer growers a high base pay combined with deducts that punish growers for poor performance. When asset specificity is added, it allows the processor to reduce the amount of rents to growers while maintaining self-enforcing contracts.

In the case of symmetric information about an exogenous shock, government regulation of contracts via termination damages would not reduce a processor's ability to design effective incentives and would therefore not be distortionary. However, regulation would cause rational processors to factor the expected future liabilities from termination into their contract design problem. As such, growers can expect to earn less per period in the shadow of a termination damages law. Nonetheless, such a regulation would protect growers ex post by compensating them for the loss value of their relationship-specific assets. In the case of asymmetric information about an exogenous shock, the results show that government regulation of contracts via termination damages seems not to reduce a processor's ability to design effective incentives and would therefore not be distortionary. However, the processor will default on her obligation of making promised payments since she can earn more by doing so. Then, growers earn either more or less under the regulation than under no regulation. These results show that before policy-makers adopt regulation such as termination damages, they need to investigate distributional consequence more carefully.

ESSAY 2

TERMINATION DAMAGES AND RELATIONAL CONTRACTS IN MORAL HAZARD WITH SUBJECTIVE PERFORMANCE MEASUREMENT

CHAPTER 7

INTRODUTION

The second essay is closely related to the first. For this reason, I will first address the main differences between the two essays and then move on to the main part of this essay. In the first essay, performance (i.e., the principal's benefit) is assumed to be commonly observed by both the principal and agent and there are no disagreements regarding the performance outcome. However, in practice, firms often make extensive use of subjective performance reviews such as the opinions of supervisors or managers as their incentive devices. Thus, there is potential for disagreements about performance assessments.

Subjective performance measures are defined as "an indicator used to assess individuals' aggregated perceptions, attitudes, or assessments toward an organization's product or service" (Wang and Gianakis, 1999). In general, such subjective performance measures are necessary when objective measures based on quantitative data on performance are impossible. For example, in the relationship between the integrator and the grower, the integrator's view of performance, such as the grower's degree of "cooperation" with the integrator or the grower's willingness to remain flexible and upgrade facilities at the integrator's request, may be particularly subjective. Moreover, the Farmers' Legal Action Group, Inc. (2001) reports that many broiler contracts include a document (e.g., Company's Broiler Growing Guide) to be used to set up standards for measuring growers' performances. However, broiler contracts commonly include terms that provide the processor/integrator with the authority and discretion to determine the growers' performance and the adequacy of facilities or equipment. For instance, processors in some livestock sectors weigh the animals themselves and determine mortality rates without a third party present (Hamilton, 1995). Moreover, in some cases, the methods and formulas used to determine performance are held privately by the integrators, so there is concern that integrators have the power to renege on promised bonuses or premiums by not reporting performance truthfully.

When the level of performance is measured subjectively by the principal, optimal relational contracts have different characteristics than those developed in the case in which the level of performance is measured objectively by the principal and agent (Levin, 2003). Therefore, in addition to the analyses provided in the first essay, it is necessary to analyze the potential impact of government-imposed termination damages on incentive design, efficiency, and the distribution of surplus between the principal and the agent in an environment where performance is observed and measured subjectively by the principal. I also extend Levin's findings on optimal relational contracts under subjective performance measures by introducing the principal's ex post full bargaining power, asset specificity, and an exogenous shock into his model.

CHAPTER 8

OPTIMAL TERMINATION CONTRACTS

8. 1. Termination Contracts

The basic model assumptions of this essay are the same as those of the first essay with the exception that the principal subjectively measures performance. As such, I will not discuss modeling assumptions and notation already introduced in the first essay; instead, I will only focus on new notation introduced in this essay. I adopt Levin's (1999, 2003) subjective performance measures model in which the agent chooses effort, e_t, privately and the principal privately observes benefit, a_t. Having observed a_t, the principal reports a message, $m_t \in \mathrm{M}$ on the level of benefit, where M is some large set of possible messages. A total payment at time *t* consists of a fixed payment, w_t, and a bonus payment, $b_t : \mathrm{M} \to R$. I maintain all the assumptions on the agent's cost function, $c(e_t \mid I)$, and the cumulative distribution function of benefit, $F(a_t \mid e_t)$, of the first essay. I also use all the notations that are defined in the first essay.

I will begin by describing the basic features of Levin's subjective performance measures model. Because the bonus payment must depend on the principal's message, m_t, an optimal contract should induce the principal's truthful reporting about the actual level of benefit. The principal will make distinct messages, m and m', in response to any two distinct benefits, a and a', if two messages yield the same future expected payoffs to the principal. Thus, if a relational contract is to provide the agent with the incentive to exert effort and, at the same time, provide the principal with the incentive to report benefit truthfully, the agent's future expected payoff must vary with performance (i.e., benefit) but the principal's must not. Levin (2003) shows that under subjective performance measures, a stationary contract cannot implement a positive effort level, but a termination contract is optimal among all contracts with the full review property.[19] In order to provide both parties with incentives, the parties can use a combination of instant rewards, such as bonus payments, and the termination of a relationship instead of using continuation payoffs varying with benefit.

Levin (2003) defines a termination contract as follows.

DEFINITION: *A contract is a termination contract if in every period t that trade occurs,* $w_t = w^m + b(a_t),\ e_t = e,\ m_t = a_t$, *and trade continues beyond t with probability* $\alpha_t = \alpha(a_t)$ *and otherwise ceases forever, for some* $w^m \in R,\ b: A \to R,\ e \in [0, \bar{e}]$, *and* $\alpha: A \to [0,1]$.

A termination contract is similar to a stationary contract in that it requires the same payment plan and effort level in each period that trade occurs, but it also allows for the

[19] Full review property means that the principal provides a full performance evaluation after each period. More formally, given any history up to *t* and payment offer (w_t and $b_t : \mathrm{M} \to R$) at *t*, any two benefits $a_t \neq a'_t$ must generate distinct messages $m_t \neq m'_t$.(Levin, 2003)

possibility that the parties will end the relationship for certain levels of performance. A more important finding by Levin is that an optimal termination contract has a "one-step" bonus schedule, $b(a)$, and at the same time a "one-step" continuation probability schedule, $\alpha(a)$. That is, the principal penalizes the agent by terminating the relationship if the principal's benefit is lower than a certain cut-off point. Otherwise, the principal compensates the agent by paying the promised bonus and continuing the relationship at least into the next period.

8. 2. Ex Post Full Bargaining Power, Asset Specificity, and Exogenous Shocks

In the previous section, I introduced the characteristics of a termination contract developed by Levin (2003) in the special case that there is no ex post bargaining power on the side of the principal, no asset specificity of investment on the side of the agent, and no exogenous shock. In this section, I analyze how a termination contract is impacted by the introduction of ex post full bargaining power, asset specificity, and an exogenous shock as was done in the first essay. I also characterize optimal termination contracts.

First, I explain the conditions for a contract to be self-enforcing.[20] Suppose there exists a full review contract that specifies effort e, a fixed payment w^m, a bonus schedule $b(a)$, and continuation payoffs $u(a)$ and $\pi(a)$ varying with the benefit, a, in the

[20] The conditions are obtained by applying my model assumptions and notations to Levin's.

initial period. A total payment schedule is defined as $w(a) = w^m + b(a)$ and both parties' expected per-period payoffs are:

$u \equiv (1-\delta)E_a[w(a) - c(e) \mid e] + p\delta E_a[u(a) \mid e] + (1-p)\delta\widetilde{u}$,

$\pi \equiv (1-\delta)E_a[a - w(a) \mid e] + p\delta E_a[\pi(a) \mid e] + (1-p)\delta\overline{\pi}$,

and $s \equiv u + \pi$.

This contract is self-enforcing if and only if:

(i) $u \geq \overline{u}$ and $\pi \geq \overline{\pi}$ (Participation constraints for A and P),

(ii) $e \in \arg\max_{\widetilde{e}} E_a\left[b(a) + p\frac{\delta}{1-\delta}u(a) \mid \widetilde{e}\right] - c(\widetilde{e})$ (Incentive-compatibility constraint),

(iii) $-b(a) + p\frac{\delta}{1-\delta}\pi(a) = -b(a') + p\frac{\delta}{1-\delta}\pi(a'),\ \forall a, a' \in A$ (Truthful reporting constraint),

(iv) $-b(a) + p\frac{\delta}{1-\delta}\pi(a) \geq p\frac{\delta}{1-\delta}\pi_{-G|x_G},\ \forall a \in A$ (Discretionary payment constraint for P),

(v) $b(a) + p\frac{\delta}{1-\delta}u(a) \geq p\frac{\delta}{1-\delta}\widetilde{u},\ \forall a \in A$ (Discretionary payment constraint for A),

(vi) for all a, a pair of the continuation payoffs, $u(a)$ and $\pi(a)$ correspond to a self-enforcing contract.

Following Levin's (1999) terminology, I call the environment of the first essay *moral hazard with common monitoring* since both parties can observe the principal's benefit. I call the environment of this essay *moral hazard with subjective performance measures*. The main difference between the two environments is that, with subjective performance measurement and moral hazard, the constraint (iii) is added. When satisfied, this constraint incentivizes the principal to truthfully report the level of a. Intuitively, since the principal has an identical expected payoff regardless of which level of benefit the principal reports, the principal has no incentive to make a false report on the actual level of benefit. I will characterize a termination contract as a list $\left(w^m, w^s, b(a), \alpha(a), e, \pi, u\right)$ that includes a continuation probability schedule, $\alpha(a)$, in addition to the stationary contract $\left(w^m, w^s, b(a), e, \pi, u\right)$ from moral hazard with common monitoring. The next proposition allows us to restrict our attention to termination contracts. That is, when any full review contract described above achieves the optimal surplus, s^*, there exists a termination contact that yields the same surplus.

PROPOSITION 1: *When* $\pi \geq \pi_{-G|x_G} \geq \overline{\pi} \geq \pi_{-G|x_B}$, $\overline{u} \geq \widetilde{u}$, $\pi_{|x_B} + u_{|x_B} < \overline{\pi} + \widetilde{u}$, *and* $x = \{x_G, x_B\}$ *with* $p = prob(x_G)$ *and* $1 - p = prob(x_B)$, *if an optimal full review contract exists, a termination contract can achieve this optimum.*

Proofs for all remarks and propositions are provided in Appendix B.

Summarizing the conditions for the self-enforcement of a termination contract used in the proof, a termination contract $\left(w^m, 0, b(a), \alpha(a), e, \pi, u\right)$ is self-enforcing if and only if the following conditions hold:[21]

(1) $\pi \equiv (1-\delta)E_a[a - w^m - b(a) \,|\, e] + p\{\delta\pi_{-G|x_G} + \delta E_a[\alpha(a) \,|\, e](\pi - \pi_{-G|x_G})\} + (1-p)\delta\overline{\pi} \geq \overline{\pi}$

(Participation constraint for P),

(2) $u \equiv (1-\delta)E_a[w^m + b(a) - c(e) \,|\, e] + p\{\delta\widetilde{u} + \delta E_a[\alpha(a) \,|\, e](u - \widetilde{u})\} + (1-p)\delta\widetilde{u} \geq \overline{u}$

(Participation constraint for A),

[21] I restrict attention only to termination contracts having $w^s = 0$ until I introduce government-imposed termination damages.

(3) $e \in \arg\max_{\tilde{e}} E_a \left[b(a) + p\frac{\delta}{1-\delta}\alpha(a)(u - \tilde{u}) \mid \tilde{e} \right] - c(\tilde{e})$ (Incentive-compatibility constraint),

(4) $p\frac{\delta}{1-\delta}\alpha(a)(\pi - \pi_{-G|x_G}) \geq b(a)$, $\forall a \in A$ [22] (Discretionary payment constraint for P),

(5) $p\frac{\delta}{1-\delta}\alpha(a)(u - \tilde{u}) \geq -b(a)$, $\forall a \in A$ [23] (Discretionary payment constraint for A),

(6) $p\frac{\delta}{1-\delta}\alpha(a)(\pi - \pi_{-G|x_G}) - b(a)$ is constant in a.[24] (Truthful reporting constraint)

From now on, I investigate the characteristics of a termination contract in the case that the principal has ex post full bargaining power and there is no asset specificity of investment (i.e., $\pi = \pi_{-G|x_G}$ and $\tilde{u} = \bar{u}$) in order to look into the pure impact of the principal's ex post full bargaining power on a termination contract. Remark 1 states that the agent earns positive rents from a termination contract when the principal has ex post full bargaining power and there is no asset specificity of investment.

[22] It is the simplified expression of the following:
$$-b(a) + p\left(\alpha(a)\frac{\delta}{1-\delta}\pi + (1-\alpha(a))\frac{\delta}{1-\delta}\pi_{-G|x_G}\right) + (1-p)\frac{\delta}{1-\delta}\bar{\pi} \geq p\left(\frac{\delta}{1-\delta}\pi_{-G|x_G}\right) + (1-p)\frac{\delta}{1-\delta}\bar{\pi}$$

[23] It is the simplified expression of the following:
$$b(a) + p\left(\alpha(a)\frac{\delta}{1-\delta}u + (1-\alpha(a))\frac{\delta}{1-\delta}\tilde{u}\right) + (1-p)\frac{\delta}{1-\delta}\tilde{u} \geq \frac{\delta}{1-\delta}\tilde{u}\,.$$

[24] It is simplified from:
$$-b(a) + p\left(\alpha(a)\frac{\delta}{1-\delta}\pi + (1-\alpha(a))\frac{\delta}{1-\delta}\pi_{-G|x_G}\right) + (1-p)\frac{\delta}{1-\delta}\bar{\pi} =$$
$$-b(a') + p\left(\alpha(a')\frac{\delta}{1-\delta}\pi + (1-\alpha(a'))\frac{\delta}{1-\delta}\pi_{-G|x_G}\right) + (1-p)\frac{\delta}{1-\delta}\bar{\pi}, \forall a, a'$$

REMARK 1: *When the principal has ex post full bargaining power (* $\pi = \pi_{-G|x_G}$ *) and there is no asset specificity (* $\tilde{u} = \bar{u}$ *), if there exists a termination contract to implement* $e > 0$ *, then the agent earns positive rents (* $u - \bar{u} > 0$ *).*

In the proof, I show that a bonus schedule should be constant in *a,* by using only the truthful reporting constraint. Therefore, this property should continue to hold when the principal has ex post full bargaining power regardless of the asset specificity of investment. It corresponds to MacLeod and Malcomson's (1998) theory that "any subjective performance pay such as a bonus contingent on performance is not credible in a market where a firm can always fill its vacancy without any cost instantly after reneging on the promised bonus since the number of workers who want jobs is greater than that of jobs." Remark 1 conversely states that if the agent's expected per-period payoff is binding at $\bar{u}$, any termination contract to implement $e > 0$ is not possible. Also, I confirm that if there exists a full review contract to implement $e > 0$, the agent earns positive rents. Therefore, the positive rents $(u - \bar{u} > 0)$ are crucial for the existence of any type of relational contract when the principal has ex post full bargaining power. This result corresponds to some degree to the theory that efficiency wages should be used to motivate employees when firms can find other employees without any loss after firing or quitting. However, there is one critical difference between my results and previous results from the literature. In the literature, possible dismissal of the agent (or employee) works as just a threat and the principal (or employer) does not fire the agent who exerts a required effort level except for some exogenous reasons, as reported in the previous literature (see Shapiro and Stiglitz, 1984; MacLeod and Malcomson, 1998)[25]. However, in the model of this essay, dismissal is not just a threat but is actually exercised for some performance contingencies and even if the agent exerts the required effort level.[26]

The next remark shows that if there exists a self-enforcing termination contract, its bonus schedule should be constant in the benefit, *a*, while the continuation probability may vary with *a*.

REMARK 2: *When* $\pi = \pi_{-G|x_G}$ *and* $\tilde{u} = \bar{u}$ *, if there exists a self-enforcing termination contract implementing* $e > 0$ *, then i) the continuation probability schedule is not constant in a and ii) the bonus schedule is constant in a and non-positive for* $\forall a \in A$*. Moreover, such a bonus schedule can be replaced by a zero bonus schedule,* $b : A \to 0$*.*

The implication of this remark is that since a non-constant bonus schedule is not available as an incentive device to the principal, a combination of the non-constant continuation probability schedule and positive rents should be used to induce the agent to exert a required effort level. The fact that any positive constant bonus schedule can be replaced with a zero bonus schedule allows us to restrict our attention to a zero bonus schedule in later analyses.

From now on, as the main part of this section, I derive the structure of an optimal self-enforcing termination contract when $\pi_{-G|x_G} = \pi$ and $\tilde{u} < \bar{u}$. In this case, a zero

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[25] In both Shapiro and Stiglitz's model and MacLeod and Malcomson's model, a worker is never fired if he exerts a required effort level unless exogenous factors induce dismissal. However, in my model, dismissal can occur even if an exogenous shock is favorable to the agent.

[26] Levin's result also shows that termination can actually occur even if an agent does not shirk. However, he does not relate it to the theory of efficiency wages.

bonus schedule, $b: A \rightarrow 0$, should hold as this property can be derived regardless of the asset specificity of investment. Since the zero bonus schedule alone cannot induce the agent to exert any positive effort level, the continuation probability schedule, $\alpha(a)$, varying with a is necessary to motivate the agent. These results are the same as those in the previous case of $\pi_{-G|x_G} = \pi$ and $\tilde{u} = \bar{u}$. However, one important difference is that under $\tilde{u} < \bar{u}$ due to asset specificity, the principal can induce the agent to exert a positive effort through the continuation probability schedule, $\alpha(a)$, varying with a in the incentive-compatibility constraint, even when the agent's expected per-period payoff is binding at $\bar{u}$. Therefore, positive rents of $u - \bar{u}$ for the agent are not always necessary.

Since the principal has ex post full bargaining power, it is natural that the principal is assumed to be interested in maximizing the principal's own profit rather than surplus, which is the sum of both parties' payoffs. When a bonus schedule is zero for $\forall a \in A$, an optimal self-enforcing termination contract can be characterized by analyzing the principal's contract design problem:

(P1) $\max\limits_{e, w^m, \alpha(a)} E_a[a - w^m \mid e]$

$$\text{s.t. } u = \tilde{u} + \frac{(1-\delta)(w^m - c(e) - \tilde{u})}{1 - p\delta E_a[\alpha(a) \mid e]} \geq \bar{u} \qquad (\text{PC}_1),$$

$$e \in \arg\max_{\tilde{e}} E_a\left[p \frac{\delta}{1-\delta} \alpha(a)\big(u - \tilde{u}\big) \mid \tilde{e} \right] - c(\tilde{e}) \quad (\text{IC}_1), \text{ and}$$

$$0 \leq \alpha(a) \leq 1, \forall\, a \in A..$$

The objective function is obtained by substituting $\pi_{-G|x_G} = \pi$ and $b(a) = 0$ for $\forall a \in A$ into the first equality of (1) and simplifying it. The equality of the agent's participation constraint (PC_1) is obtained by substituting $b(a)=0$ for $\forall a \in A$ into (2) and rearranging it. The incentive-compatibility constraint (IC_1) is acquired by substituting $b(a)=0$ for $\forall a \in A$ into (3). Both parties' discretionary payment constraints and truthful reporting constraint are not necessary, since these are naturally satisfied when $\pi_{-G|x_G} = \pi$ and $b(a)=0$ for $\forall a \in A$ are substituted into (4)-(6) and (PC_1) holds. The principal's participation constraint ($\pi \geq \overline{\pi}$) is not included due to the assumption that it is satisfied.

Under the Mirrlees-Rogerson condition, (IC_1) can be replaced with

(7) $p\dfrac{\delta}{1-\delta}\left(u-\widetilde{u}\right)\dfrac{d}{de}E_a[\alpha(a)\mid e]-c'(e)=0$.[27]

(PC_1) can be rewritten as $(1-\delta)\left(w^m - c(e)-\widetilde{u}\right) \geq (\overline{u}-\widetilde{u})\left(1-p\delta\, E_a[\alpha(a)\mid e]\right)$. Then, (P1) is converted into the following program:

(P2) $\max\limits_{\alpha(a),w^m,e} E_a[a-w^m \mid e]$

s.t. $(1-\delta)\left(w^m - c(e)-\widetilde{u}\right)-(\overline{u}-\widetilde{u})\left(1-p\delta\, E_a[\alpha(a)\mid e]\right) \geq 0$ (PC_2),

$p\delta(w^m - c(e)-\widetilde{u})\dfrac{d}{de}E_a[\alpha(a)\mid e]+p\delta E_a[\alpha(a)\mid e]c'(e)-c'(e)=0$ (IC_2), and

$0 \leq \alpha(a) \leq 1, \forall a \in A.$

(IC_2) is obtained by substituting the equality of (PC_1) into (7) and rearranging it. The following proposition characterizes an optimal self-enforcing termination contract that is derived by solving (P2).

[27] Refer to Laffont and Martimort (2002) for further details of the condition.

PROPOSITION 2 : *When* $\tilde{\pi} = \pi_{-G|x_G}$ *and* $\tilde{u} < \bar{u}$ *, if there exists an optimal self-enforcing termination contract* $\left(w^m, 0, b(a), \alpha(a), e, \pi, u\right)$*, it has the following characteristics.*

(i) $b(a)$ *is zero for* $\forall a \in A$.

(ii) $\alpha(a) = 0$ *for* $\forall a < \hat{a}$ *and* $\alpha(a) = 1$ *for* $\forall a \geq \hat{a}$.

(iii) the cut off value, $\hat{a}$ *, is less than the level that satisfies* $f_e(a \mid e)/f(a \mid e) = 0$.

(iv) u is either equal to or larger than $\bar{u}$.

This proposition outlines the common characteristics (i)-(iii) that any optimal self-enforcing termination contract should take and states that whether or not the agent's expected per-period payoff is either binding at $\bar{u}$ depends on the exogenous parameters as $p, \delta, \tilde{u}$, and $\bar{u}$. Part (i) means that the principal cannot employ a performance-contingent bonus schedule to motivate the agent when the principal has ex post full bargaining power. This is the most important distinction with respect to Levin (2003)'s result. When the principal can change a trading partner without any loss due to ex post full bargaining power and the principal's assessment on the agent's performance is subjective, the agent does not believe that bonus payments contingent on the principal's assessment will actually be paid. Therefore, the principal's ex post full bargaining power combined with subjective evaluation on performance can explain why "performance pay" is sometimes not employed as an incentive device. Part (ii) states that a one-step continuation probability schedule is essential to motivate the agent. Part (iii) states that the interval of benefit by specifying rewards through a continuation probability schedule under moral hazard with subjective performance measures is larger than the interval of benefit by specifying rewards through a bonus schedule under moral hazard with common monitoring. These two results are analogous to Levin's. However, while he points out that joint punishment or disputes due to termination are indispensable in equilibrium, in the model of this essay, termination punishes only the agent since the principal never takes any loss by making a new contract with another agent. Part (iv) states that the principal in some cases wants to provide the agent with positive rents (i.e., $u-\bar{u}>0$) in order to maximize the principal's own expected per-period payoff by motivating the agent to exert more effort. This is because the agent's choice of effort level depends on u as seen in (IC_1). For any given one-step continuation probability schedule, (IC_1) becomes $e \in \arg\max_{\tilde{e}} \frac{p\delta}{1-\delta}(1-F(\hat{a}\mid\tilde{e}))(u-\tilde{u})-c(\tilde{e})$. The first-order condition is $-\frac{p\delta}{1-\delta}F_e(\hat{a}\mid e)(u-\tilde{u})-c_e(e)=0$. By the implicit function theorem, we know $\frac{de}{du}=-\frac{p\delta}{1-\delta}F_e(\hat{a}\mid e)\Big/\left\{\frac{p\delta}{1-\delta}(u-\tilde{u})F_{ee}(\hat{a}\mid e)+c_{ee}(e)\right\}>0$,

which implies that as more rents are provided to the agent, the effort level chosen by the agent increases, so the principal's expected benefit also increases. However, the principal's expected payoff may decrease due to increased rents. Therefore, when positive rents are optimal $(u-\bar{u}>0)$, the marginal benefit of the agent's rents is equal to the marginal cost of it. On the other hand, when no rents are optimal ($u=\bar{u}$), the marginal benefit of the agent's rents is less than the marginal cost of it. In this case, the principal actually would want to reduce u more but cannot do that due to the agent's participation constraint.

CHAPTER 9

IMPACT OF TERMINATION DAMAGES

In this chapter, I analyze the impact of government regulations on relational contracts with subjective performance measures. The focus will be on the distributional and efficiency consequences of regulation so the analyses are normative rather than positive. I do not conduct positive analyses, such as the political economy of regulation and do not address issues pertaining to why such legislation has been proposed. Termination can occur due to two distinct reasons. One reason is a negative exogenous shock. The other reason is punishment following poor performance (i.e., low benefit). Termination damages (or severance payments) are paid to the agent by the principal when the contractual relationship is separated for either of the two reasons. The following proposition states the impact of termination damages (or severance payments) of an arbitrary size.

PROPOSITION 3: *When* $\pi = \pi_{-G|x_G}$ *and* $\tilde{u} < \bar{u}$, *if there exists an optimal self-enforcing termination contract* $\left(w^m, 0, 0, \alpha(a), e, \pi, u\right)$, *for any* $w^s > 0$ *there exists an optimal self-enforcing termination contract* $\left(w^m - \delta w^s, w^s, b(a), \alpha(a), e, \pi, u\right)$, *where* $b(a) = 0$ *and* $\alpha(a) = 0$ *for* $\forall a \le \hat{a}$, *and* $b(a) = p\delta w^s$ *and* $\alpha(a) = 1$ *for* $\forall a > \hat{a}$.

When the severance payment w^s is mandated, the principal can design an optimal self-enforcing termination contract to have the same $(\alpha(a), e, \pi, u)$ as the contract under no severance payments by reducing the fixed payment by δw^s and setting $b(a) = p\delta w^s$ for all $a > \hat{a}$ and $b(a) = 0$ for all $a \leq \hat{a}$. An important change is that the non-constant bonus schedule becomes possible since termination is not costless to the principal any longer.

A difference between proposition 3 of the first essay and proposition 3 of this essay is that while the bonus payments for all $a \in A$ increase in the first essay, bonus payments for all $a > \hat{a}$ increase in this essay. Apart from this difference, the impact of the regulation on efficiency and distribution is identical to that of the first essay. That is, termination damages, of whatever size, would have no impact on efficiency and distribution of surplus yielded from the contractual relationship between two parties, even when the principal has ex post full bargaining power and imposes asset specificity on the agent. Thus, the principal can structure effective incentives even though termination damages are required by law. Since termination damages do not affect the principal's ability to structure incentives, regulation may seem unnecessary. Termination damages, however, do increase (decrease) the payoff that the agent (principal) earns after the relationship is terminated contingent on the bad state. Because proposition 3 suggests that imposing termination damages on contractual relationships would not be distortionary, it matters little whether or not damages are imposed from an efficiency perspective. Nonetheless, policy-makers might be tempted to use damages to redistribute rents across different states of nature although this is a political economy question. As a final comment, I point out that if termination damages were imposed, the principal would factor the expected liabilities into the compensation plan, ex ante. Hence, the payoff w^m that the agent earns in each period during the course of the relationship is lower by δw^s than the payoff without regulated damages.

CHAPTER 10

CONCLUSION AND IMPLICATION

This essay analyzes optimal self-enforcing termination contracts under the assumptions that agents (e.g. growers) must make relationship-specific investments prior to contracting and that principals (e.g. processors) have ex post full bargaining power due to monopsony power and subjectively measure performance. I also analyze the potential impact of government-imposed termination damages on incentive design, efficiency, and the distribution of surplus between processors and growers. My primary findings are that, in the optimal self-enforcing termination contract, the processor motivates the grower by rewarding the grower through continuation of the relationship for high levels of performance (i.e., benefit) and penalizes the grower through termination for low levels of performance. Performance bonuses are no longer used. The processor also sometimes provides the grower with positive rents in order to maximize the processor's own profit. Surprisingly, government regulation of contracts via termination damages would not reduce the processor's ability to design effective incentives and would therefore not be distortionary. However, the regulation would cause rational processors to factor into their contract design problem the expected future liabilities from termination. As such, growers can expect to earn less during the course of contractual relationships in the shadow of a termination damages law. Nonetheless, such regulation would protect growers ex post by compensating them for the loss in value of their relationship-specific assets, although risk-neutral growers may be indifferent so long as ex ante expected payoff is unchanged.

Finally, the incentive structure with moral hazard and subjective performance measure is quite different from that in the case with common monitoring. However, when both parties have the same information about exogenous shocks that affect productivity of contractual relationships, the potential impact of government imposed termination damages on efficiency and the distribution of surplus between processors and growers is the same.

ESSAY 3

SELF-SERVING BIASES IN AN INCOMPLETE CONTRACTING GAME: AN EXPERIMENTAL STUDY

CHAPTER 11

INTRODUCTION

The self-serving bias (hereafter, SSB), which frequently occurs when individuals make judgment on the probabilities of certain outcomes that are beneficial to themselves, has been considered by economists as one of the important psychological factors that affect human behavior. Many economists have shown the existence of SSB through various kinds of experimental studies and have incorporated SSB into economic analysis (Binmore et al., 1989; Knez and Camerer, 1995; Babcock et al., 1995; Kagel et al., 1996; Babcock and Loewenstein, 1997; King, 2002). On the other hand, SSB is considered one of the modeling principles that standard game theory cannot fully incorporate, along with concerns about fairness, framing effects, and awareness of certain focal points (Camerer, 1997).[28] Camerer states that a difference in the bargainers' perceptions of fairness, which is self-serving in terms of that one bargainer generally wants more than the other bargainer considers to be fair and vice versa, could exacerbate conflicts such as divorces, wars, and strikes.

The evidence for SSB has been observed in various kinds of research. SSB is evident when more than half of survey respondents answer that they are included in the

[28] Camerer uses the term overconfidence instead of SSB. Since Babcock and Loewenstein (1997) use SSB to describe the same phenomenon without distinction, I use the term SSB in this essay.

top 50 percent of a specific group (e.g. teachers, drivers, managers, etc.).[29] This phenomenon is called the "above average" effect (Babcock and Loewenstein, 1997). SSB is also evident in some research showing that people think that their own contributions to joint work are greater than partners' contributions (Ross and Sicoly, 1979; Zuckerman, 1979). The existence of SSB has also been investigated through several bargaining game experiments (Roth and Murnighan, 1982; Loewenstein et al., 1993; Babcock et al., 1995) and an auditing trust game experiment (King, 2002). In the most notable bargaining experiment conducted by Babcock and Loewenstein (1997), subjects play the role of either a plaintiff or a defendant, guess the amount that the judge would award and what amount of settlement is fair, and negotiate the amount of settlement. The study shows that there is a significant gap between the plaintiff's guess about the expected judgment and the defendant's, which implies the existence of SSB. Babcock and Loewenstein provide experimental evidence that SSB is an important determinant of "bargaining impasse." They also explain the cause of SSB and suggest ways to get rid of it by using "debiasing" techniques such as weakness listing.[30]

However, whether SSB exists in an incomplete contract in which contract terms are unenforceable and what causes SSB have not been investigated to my knowledge.[31] It might also be interesting to investigate how individuals' strategic behavior such as the decision to accept or reject contract offers changes with the evolution of SSB across time.

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[29] Refer to Babcock et al. (1995) and Babcock and Loewenstein (1997) for various examples of SSB.
[30] They showed that when subjects do not know their roles before negotiation started, subjects have no significant biases and settle more rapidly and more frequently. A subject's information about his or her own position in bargaining causes SSB, thus reducing the possibility of settlement. The information can be thought to provide the subject with a focal point of bargaining (negotiating).
[31] The term "incomplete" means that the important obligations and terms, such as price, quantity, time of delivery, and quality, of the contracting parties are not clearly specified (Edlin and Reichelstein, 1996). Hence, a third party such as a court cannot enforce the obligation and terms.

Thus, the goal of this essay is to investigate whether SSB is an important determinant of subjects' strategic behavior in a multi-period incomplete contract environment. The specific objectives of this study are first to examine the existence of SSB in a multi-period incomplete contracting game, second to examine the causes of SSB, and third to investigate the effect of SSB on economic behavior that determines the level of surplus from a contract.

The experimental design of an incomplete contracting game involved randomly assigning human subjects to be either "buyers" or "sellers." In each experiment, there were five buyers and seven sellers. Buyers made contract offers that specified desired quality and desired price in each of 15 trading periods. If a seller accepted an offer in any period, she then chose actual quality that determined payoffs for that period. Actual quality could differ from desired quality. Then, the buyers paid to the sellers an actual price that could also differ from desired price. Since both desired quality and desired price are unenforceable, the contracts are incomplete. Moreover, the seller's choice of actual quality could be conditioned on the seller's expectation about the actual price she would receive from the buyer. So, the possibility existed that a seller had biased expectations; i.e., expectations that were systematically higher or lower than the actual price received. When the seller's expectation was greater than the buyer's actual price, it is concluded that the seller had SSB. Thus, SSB potentially existed in any given period, which could have affected the seller's behavior in the next period. To rule out the possibility that buyers and sellers could engage in repeated relationships and form reputations, each buyer and seller was assigned a buyer ID number or a seller ID number at the start of each period, with the ID numbers changing from period to period.

The incomplete contracting game is closely related to a trust game. Trust has been identified as an important factor for explaining human behavior that cannot be explained by economic theories that assume individuals always act for their own self-interests and have perfect rationality. Trust is defined as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the Trustor, irrespective of the ability to monitor or control the other party” (Mayer et al., 1995). Trust can also be defined in a trust game: When a first mover lends money to a second mover who does not have to repay the first mover, the first mover trusts the second mover. A seller’s level of actual quality in the incomplete contracting game corresponds to a first mover’s level of trust in a trust game. A seller chooses actual quality, producing some surplus for a buyer who does not have to pay a seller any price, with the expectation that a buyer will pay as compensation some portion of the surplus produced by a seller. Although some researchers have analyzed the evolution of subjects’ strategic behavior in a repeated trust game (e.g., Engle-Warnick and Slonim, 2004), no study on such a topic has been done in an incomplete contracting game that is more flexible in subjects’ choices. In addition, no study explaining the evolution of trust in a trust (or incomplete contract) game by considering SSB has been performed to my knowledge.

The main findings are as follows. First, SSB exists in the aggregate. Second, the difference among subjects’ responses to the unenforceable contract term such as desired price can create SSB and affect the size of it. The difference among subjects’ responses to the discrepancy between desired quality and actual quality also affects SSB. These results are somewhat consistent with King's (2002) results.[32] He shows that in an auditing trust game between a manager and an auditor, a manager's use of "cheap talk" such as puffery, which is costless, nonbinding, and irrelevant to payoffs, may create SSB in an auditor by increasing an auditor's perception of a manager's trustworthiness. In the incomplete contracting game experiment, desired price and desired quality can be thought of as cheap talk since they are costless, unenforceable, and irrelevant to payoffs. Third, SSB has no significant effect on the sellers' decisions to reject or accept any offer, which are mainly affected by the sellers' payoff histories in all past contracts as well as the payoff level of the just previous contract. However, conditioned on a seller accepting an offer, SSB has a significant effect on that seller's choice of actual quality, which represents the trust level of the seller. Actual quality is affected significantly by the history of SSB as well as the history of payoffs.

A key lesson from this research is that economic factors such as the histories of payoffs are more crucial causes of bargaining impasses than are psychological factors such as SSB. If SSB does have an impact on bargaining impasses, it is indirect in that SSB negatively impacts certain key economic factors such as the level of trading surplus achieved by buyers and sellers.

[32] While in King's experiment, two subjects play several periods without the option to change an opponent subject, in the incomplete contracting game experiment any subject can change an opponent player. Another difference is that in King's experiment a puffery-action phase gives managers the possibility of conditioning the expectation of the auditors and each manager can further condition his partner's expectations during the regular play phase by sending a puffery message. However, in the incomplete contracting game experiment, the buyers can send a kind of puffery message (i.e., desired price) only when the buyers make offers to the sellers. Therefore, the experimental design of the incomplete contracting game has a much simpler condition for causing SSB than does King's experimental design.

CHAPTER 12

EXPERIMENTAL DESIGN

The multi-period two-sided incomplete contracting game (called the ICR game) was played as follows. 12 subjects participated in each experiment and were randomly divided into two groups: 5 buyers and 7 sellers.[33] Each buyer took the role of a principal, and each seller took the role of an agent. The subjects played 15 identical periods of a two-sided incomplete contracting game. Each buyer and seller was assigned a buyer ID number between 1 and 5 or a seller ID number between 1 and 7 at the start of each period, with the ID numbers changing from period to period. Therefore, the buyers could not track specific sellers' behavior in the previous periods and the sellers also could not track specific buyers' behavior.

Each period consisted of five stages. In the first stage, the buyers made contract offers to the sellers. A contract offer was a list (p_D, q_D) consisting of a price level, $p_D \in \mathrm{P} = \{0, 1, \ldots, 100\}$ (called *Desired Price*) and a quality level, $q_D \in Q = \{1, 2, \ldots, 10\}$ (called *Desired Quality*). Neither the buyer nor the seller was obligated to supply the *Desired Price* or *Desired Quality* as the contract was incomplete and unenforceable. The subscript *D* is used to denote that the specified price level and

[33] The experiment of the ICR game was conducted six times in six different days.

quality level are merely *desired* by the buyer. The buyers could make as many contract offers as they wanted. A contract offer took one of two types, a private offer or a public offer. For each private offer, the buyer indicated a seller ID number with whom the buyer wanted to make a contractual relationship. Only the indicated seller was informed of the offer. No buyer knew to which sellers the other buyers made private offers. No seller knew from which buyers the other sellers received private offers. For each public offer, the buyer did not indicate a seller ID number, so all 7 sellers were informed about each public offer. Each buyer could observe the public offers made by the other 4 buyers.

In the second stage, a seller could either accept one offer or reject all offers by not choosing any offer. After a seller accepted an offer, the buyer who had made the offer was matched with the seller exclusively for one period only. Once a buyer's offer was accepted by a seller, the buyer's remaining offers were instantly withdrawn from the experimental economy so that they were no longer available to sellers. The buyers knew which sellers remained in the experimental economy at any time until the stage terminated, which occurred when contractual relationships were established between 5 buyers and any 5 sellers or a 90-second limit expired. If a seller did not accept any offer, the seller earned a predetermined payoff (i.e., reservation payoff of $\bar{u} = 10$) in that period. If a buyer did not contract with any seller, the buyer earned a payoff of zero in that period.

Buyer-seller pairs that formed a contractual relationship for the period advanced to the third stage, in which the buyer was asked to specify the quality the buyer expected to be chosen by the seller. This quality level is denoted by $q_E \in Q = \{1, 2, \ldots, 10\}$ (called *Expected Quality*). The seller chose one of the ten quality levels. The seller did not need to choose the quality level that was specified in the accepted offer. The quality level which was actually chosen by the seller is denoted by $q_A \in Q = \{1, 2, \ldots, 10\}$ (called *Actual Quality*). The seller incurred the monetary cost for the *Actual quality* level. The monetary cost of each *Actual Quality* level denoted by $c(q_A)$ is shown in table 1.

q_A	1	2	3	4	5	6	7	8	9	10
$c(q_A)$	0	1	2	4	6	8	10	12	15	18

Table 1: Monetary cost of each *Actual Quality* level.

The seller was also asked to specify the price the seller expected to be paid by the buyer. This price is denoted by $p_E \in \mathrm{P} = \{0, 1, \ldots, 100\}$ (called *Expected Price*).

In the fourth stage, each buyer who had made a contractual relationship observed *Actual Quality*, q_A and then determined $p_A \in \mathrm{P} = \{0, 1, \ldots, 100\}$ (called *Actual Price*) to be paid to the seller. This price was not necessarily equal to *Desired Price*, p_D.

In the fifth stage, all parties' payoffs were determined. A buyer's payoff, π_B was equal to ten times *Actual quality* minus *Actual price* ($\pi_B(p_A, q_A) = 10 \times q_A - p_A$). A seller's payoff, π_S was equal to *Actual Price* minus the monetary cost of *Actual Quality* ($\pi_B(p_A, q_A) = p_A - c(q_A)$).

This experimental design was constructed from base code that was developed by Brown, Falk, and Fehr (2004). The experiment was computerized and conducted by using z-Tree software (Fischbacher, 2002). The subjects were undergraduate and graduate students from a broader range of academic departments in the Ohio State University. Recruiting at OSU was done primarily through campus e-mail lists. In each day of the experiment, the ICR game session was conducted as one part of a larger experimental study that included several different sessions.[34] All monetary values were denoted by points. The value of 70 points was $1. The subjects' actual earnings were calculated considering points in other sessions conducted on that day as well as points in the ICR game session. The experiment took approximately 2 hours. The instructions for buyers and sellers actually used in the experiments are presented in the Appendix C.

[34] Other sessions and objectives of the experiment are analyzed in other papers cited in the bibliography section. This study is one of several studies that use the data obtained from several types of contracting games.

CHAPTER 13

GAME THEORETICAL SOLUTION

I consider a game theoretical solution under the assumption that all subjects maximize their own payoffs (i.e., self-interest) and they know this fact (i.e., perfect rationality). First, suppose that a seller accepts a buyer's offer in a period. Once the seller accepts an offer made by the buyer, the seller decides *Actual Quality*, q_A, which results in a benefit of $10q_A$ for the buyer. After the buyer observes q_A, the buyer decides *Actual Price*, which can be denoted by $p_A(q_A)$ in order to explicitly represent that p_A is determined after q_A is observed by the buyer. The seller chooses the strategy q in $\{1, 2, \ldots, 10\}$, while the buyer chooses the strategy $p : \{1, 2, \ldots, 10\} \rightarrow \{0, 1, \ldots, 100\}$. Since the contract is incomplete and thus (p_D, q_D) specified by the buyer is not enforced, the selfish and perfectly rational subjects do not care about p_D and q_D, which are not relevant to subjects' strategies. The sum of the payoffs which the subject has earned up to the previous period is defined as the subject's wealth and is denoted by w_i for $i = B, S$. If the subjects have a strictly increasing indirect utility function for wealth, given by $V_i(w_i + \pi_i(q_A, p_A))$, then the buyer's dominant strategy is $p : \{1, 2, \ldots, 10\} \rightarrow \{0\}$. That is, the buyer pays the seller nothing in order to maximize V_B regardless of the level of q_A.

Since the seller infers the buyer's dominant strategy, the seller should choose $q_A = 1$. Therefore, conditioned on that the seller accepts the buyer's offer, the buyer's payoff is ten and the seller's payoff is zero in the subgame-perfect equilibrium. However, since the seller's payoff of zero is less than the reservation payoff of 10, which the seller can earn without any contractual relationship, the seller never accepts any offer. Therefore, the subgame-perfect equilibrium is that sellers do not accept any offers and buyers do not make any contract offers. (In fact, whether buyers make offers does not matter.) Under this subgame-perfect equilibrium, SSB cannot exist since the seller does not accept any offer.

CHAPTER 14

VARIABLES

14. 1. Variables of the ICR Game

In this section, I explain implications of the variables that subjects choose in the ICR game. I also define new variables derived from the variables of the ICR game, which will be necessary for later analyses on SSB.

Expected Price, p_E, which the seller specifies after the seller decides *Actual Quality*, q_A, measures the seller's estimate of the buyer's trustworthiness.[35] *Actual Price* p_A, which the buyer specifies after the buyer observes q_A, measures the buyer's trustworthiness. Therefore, the difference between p_A and p_E implies the difference between the buyer's trustworthinesss and the seller's estimate of the buyer's trustworthiness. If p_E is greater than p_A, the seller's estimate of the buyer's trustworthiness is greater than the buyer's trustworthiness. I denfine a new variable,

[35] Glaeser et al. (2000) and Camerer (2003) state that the amount sent by a first mover is a measure of trust and the amount paid back to a first mover by a second mover is a measure of trustworthiness in a trust game and an investment game. In Eckel and Wilson's (2004) trust game, first movers, immediately after deciding whether to keep or to send their endowments, are asked to specify how much second movers return, which is called expected return. This corresponds to *Expected Price* in the ICR game. However, the difference is that while even the first movers who keep their endowments are asked to specify expected return in their experiment, only the sellers who accept contract offers and decide *Actual Quality* are asked to specify *Expected Price* in the ICR game.

BiasPri, b_P, which is equal to *Actual Price* minus *Expected Price* (i.e., $b_P = p_A - p_E$). It is claimed that if *BiasPri* is negative (i.e., $p_A < p_E$) in any contract, the seller has SSB since the seller infers the buyer's trustworthiness in a manner beneficial to herself. In the ICR game, SSB can be measured without distortions from reputation-building between the buyers and the sellers, since the buyers' and sellers' ID numbers randomly change in every period.

The following table presents the variables that subjects decide in the ICR game and the variables that I define for later analyses of this study.

Variable	Description
Desired Quality, q_D	Quality level that the buyer specifies in a contract offer
Desired Price, p_D	Price level that the buyer specifies in a contract offer
Actual Quality, q_A	Quality level that the seller actually chooses
Actual Price, p_A	Price level that the buyer actually pays to the seller
Expected Quality, q_E	Quality level that the buyer expects the seller to choose
Expected Price, p_E	Price level that the seller expects the buyer to pay
BiasQual, b_q [36]	= *Actual Quality - Expected Quality*
DiffQual, d_q	= *Actual Quality - Desired Quality*
BiasQual+	$= b_q$ *if* $b_q \geq 0$, $= 0$ otherwise
BiasQual-	$= \lvert b_q \rvert$ *if* $b_q < 0$, $= 0$ otherwise
DiffQual+	$= d_q$ *if* $d_q \geq 0$, $= 0$ otherwise
DiffQual-	$= \lvert d_q \rvert$ *if* $d_q < 0$, $= 0$ otherwise
BiasPri, b_p	= *Actual Price - Expected Price*
DiffPri, d_p	= *Actual Price - Desired Price*

Table 2: Variables either collected in the ICR game or defined for analysis.

The measure of SSB in this essay differs from Babcock et al.'s (1995) and Babcock and Loewenstein's (1997). They measure SSB as both the discrepancy between plaintiffs' and defendants' assessments of what a third party, such as a judge, would award in the case of no settlement and the discrepancy between plaintiffs' and defendants' assessments of a fair settlement amount. Therefore, the size of SSB is not affected by an opponent's strategic behavior. Since a plaintiff-defendant bargaining

[36] *BiasQual* may represent the buyer's SSB. However, q_A and q_E determine expected surplus and actual surplus from a contract instead of the buyer's expected payoff and actual payoff.

relationship lasts for only one period and each party cannot know about the other party's assessment, the effect of SSB on the evolution of strategic behaviors is not analyzed. On the other hand, I measure SSB as the discrepancy between one party's (i.e., seller's) *Expected Price* and the *Actual Price* decided by an opponent party (i.e., buyer). Since the sellers can know the size of SSB experienced in the past contracts, I can analyze to what extent SSB affects the evolution of subjects' behavior in the ICR game.

14. 2. Demographic and Social Preference Variables

In later regression analyses, several demographic variables and social preference variables are used in order to control for individual characteristics. Demographic information was collected through a post-experiment questionnaire. Social preference information was collected through games designed by Charness and Rabin (2002). Subjects played these social preference games before or after the ICR game. The social preference games and the classification method, which is developed by Roe and Wu (2006), allow us to assign each subject to one of the following six social preference categories: Self-Interest (SI), Competitive (C), Social Efficiency (SE), Maximin (MM), Disadvantage Inequality Aversion (DI), and Negative Reciprocity (NR).[37] The demographic and social preference variables that are used later are presented in the following table.

[37] More than half (39 subj., 54.2%) of 72 subjects are classified as Self-Interest, which is the most common social preference. The next most common social preference is Competitive (19 subj., 26.4%). There are 19 Maximin (12.5%), 4 Social Efficiency (5.6%), 1 Disadvantage Inequality Aversion (1.4%), and 0 Negative Reciprocity (0%).

Variable	Description
_age	Age
_gender	=1 if Male, =0 otherwise.
_currentwage	Wage income; it is zero when a subject is not employed.
_gpa	GPA
*_race*1	=1 if White, =0 otherwise.
*_race*2	=1 if Black, 0 otherwise.
*_race*3	=1 if Hispanic or of Spanish origin, =0 otherwise.
*_race*4	=1 if Asian or Pacific Islander, =0 otherwise.
*_race*5	=1 if American Indian or Alaskan Native, =0 otherwise.
_cla1	=1 if Freshman, =0 otherwise.
_cla2	=1 if Sophomore, =0 otherwise.
_cla3	=1 if Junior, =0 otherwise.
_cla4	=1 if Senior, =0 otherwise.
_cla5	=1 if Master student, PH. D student, or others, =0 otherwise.
_SI	=1 if Self-Interest, =0 otherwise.
_C	=1 if Competitive, =0 otherwise.
_SE	=1 if Social Efficiency, =0 otherwise.
_MM	=1 if Maximin, =0 otherwise.
_DI	=1 if Disadvantage Inequality Aversion, =0 otherwise.
_NR	=1 if Negative Reciprocity, =0 otherwise.

Note: _ ∈ {S, B}, where *S*=Seller and *B*=Buyer.

Table 3: Demographic and social preference variables.

CHAPTER 15

RESULTS

15. 1. Existence of SSB

In this section, I first present basic results such as the number of contracts, the means of contracting variables, etc. Then, it is shown that in the aggregate, SSB exists.

For all 15 periods of 6 experiments, the number of contracts (386) is about half of the number (694) of offers. When these values are presented for each period in figure 2, there are two patterns. For later periods, while the number of offers tends to increase (i.e., 35 offers in 1^{st} period, 49 offers in 8^{th} period, and 59 offers in 15^{th} period), the number of contracts tends to decrease (i.e., 28 contracts in 1^{st} period, 25 contracts in 8^{th} period, and 20 contracts in 15^{th} period). Therefore, the ratio of the number of contracts to the number of offers tends to decrease. 28 out of 35 offers are accepted in the first period (80%) but 20 out of 59 offers are accepted in the final period (34%).

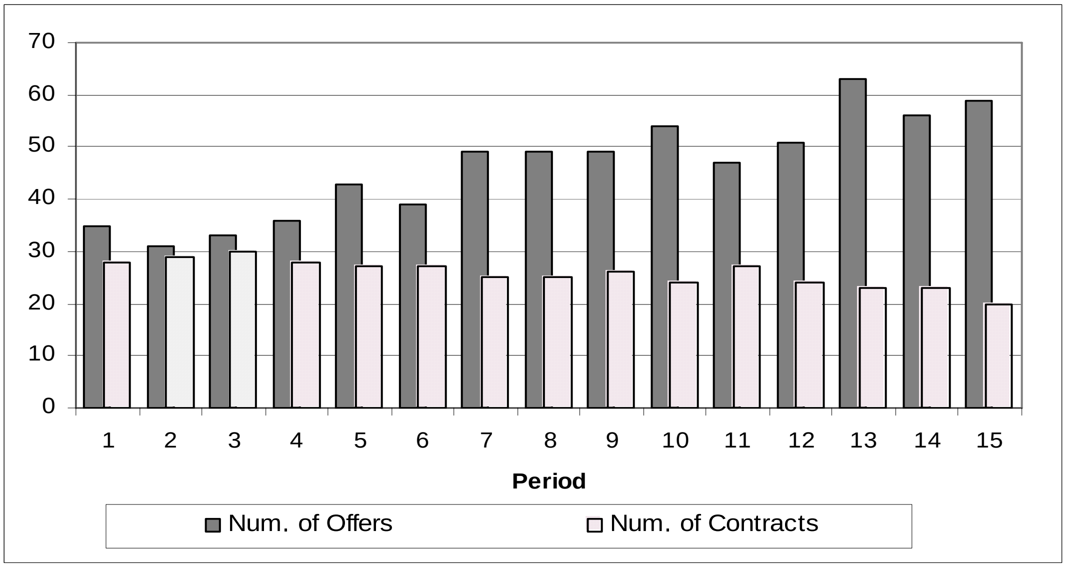


Figure 2: The number of offers and the number of contracts in each period.

This implies that as the ICR game goes on, more sellers are unwilling to accept offers. Thus, fewer buyers can make contracts with sellers although they make more offers. Therefore, the experimental contracting market gradually breaks down. Subjects' behavior seems to become closer to the game theoretical equilibrium in which no contract takes place. However, still almost half (20) of 42 sellers in the 6 experiments accept offers even in the final period.

The following table presents the means and standard deviations of the variables of the ICR game, *BiasPri*, the buyer's payoff, the seller's payoff, and surplus from a contract.

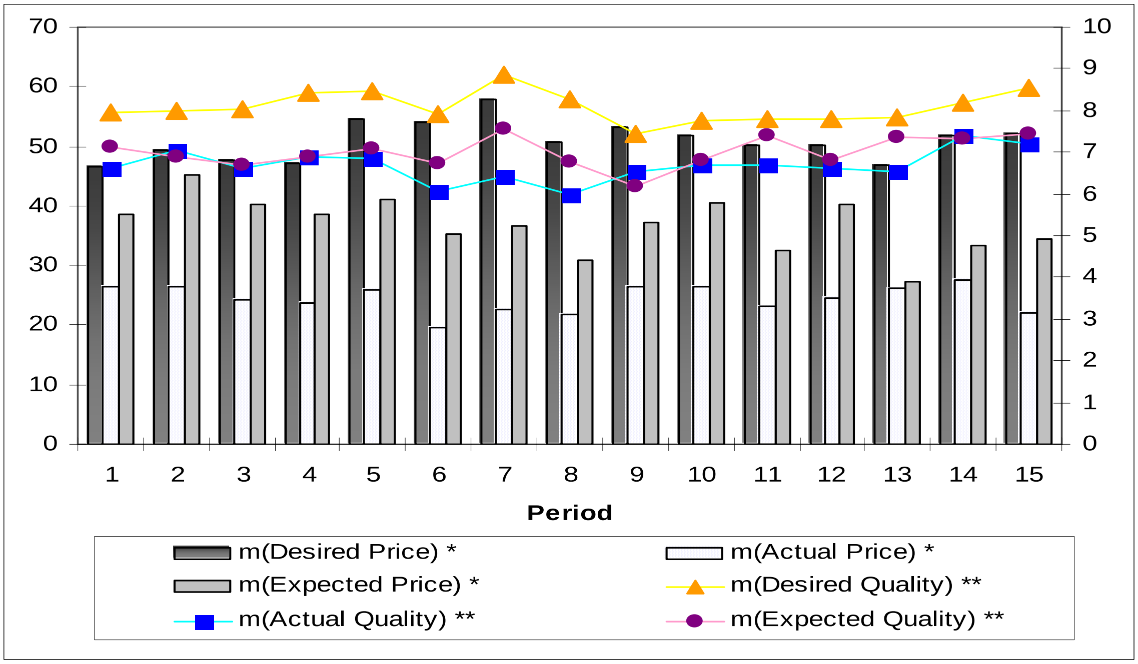
Variable	Mean	Standard Deviation
Desired Quality, q_D	8.08	2.38
Expected Quality, q_E	6.99	2.49
Actual Quality, q_A	6.67	3.18
Desired Price, p_D	50.85	17.22
Expected Price, p_E	36.97	23.27
Actual Price, p_A	24.45	20.44
BiasPri, b_P	-12.52	24.93
Buyer's Payoff, π_B	42.24	24.06
Seller's Payoff, π_S [a]	14.13	16.79
Surplus from a Contract, S [a]	56.36	25.20

a- The statistics of this variable are calculated using payoffs from contracts. So, the reservation payoff of 10 that the sellers earn with no contract is not considered.

Table 4: Summary statistics.

On average, *Actual Price* is significantly smaller than *Desired Price* since in the two-sided test with $H_0: \mu(p_A - p_D) = 0$, the *t*-statistic is -18.34 (*p*-value < 0.0001). On average, *Expected Quality* is slightly but significantly greater than *Actual Quality* since in the two-sided test with $H_0: \mu(q_E - q_A) = 0$, the *t*-statistic is 1.94 (*p*-value = 0.0497). On average, *Actual Price* is significantly smaller than *Expected Price* since in the two-sided test with $H_0: \mu(p_A - p_E) = 0$, the *t*-statistic is -9.86 (*p*-value < 0.0001). That is, the mean of *BiasPri* ($m(b_P) = -12.52$) is significantly negative, which implies that on average, the sellers have SSB. $m(\cdot)$ denotes the mean of a variable or expression in parentheses. On average, *Actual Quality* is also significantly smaller than *Desired Quality* since in the two-sided test with $H_0: \mu(q_A - q_D) = 0$, the *t*-statistic is -9.41 (*p*-value < 0.0001). On average, the sellers expect the buyers to set price below p_D (i.e., $m(p_E - p_D)$ = -13.89). It is worth noting that $m(p_E - p_D)$ = -13.89 is approximately equal to $10 \times m(q_A - q_D)$ = -14.12. On average, the sellers may expect the buyers to reduce p_A by the same amount as the difference between the maximum revenue (i.e.,$10q_D$) that the buyers can earn under q_D and that (i.e.,$10q_A$) under q_A. However, on average the buyers sets *Actual Price* far below the sellers' *Expected Price,* thus resulting in SSB.

Next, figure 3 presents the means of p_D, p_A, p_E, q_D, q_A, and q_E from 386 contracts for each period. $m(q_A)$ is smaller than $m(q_D)$ and $m(p_E)$ is smaller than $m(p_D)$ in all 15 periods. $m(p_A)$ is even smaller than $m(p_E)$ in all 15 periods. This shows that on average, the sellers who have contracts have SSB in all 15 periods. The size of SSB has a tendency to become smaller as a period is closer to the final (Figure 4). Thus, we can infer that the sellers may experience lower SSB in later periods since they decrease the likelihood of SSB by reducing p_E. We can also infer that the sellers who do not accept offers in the later periods may be those who experience high SSB frequently in the early periods. For example, the 22 sellers who do not accept any offer in the final period may have experienced the higher SSB more often in the previous periods than the 20 sellers who contract in the final period. However, we should be careful about this inference since high SSB may be related to the sellers' low payoffs. Hence, I need to disentangle the impact of SSB from the impact of the low payoffs, which will be done in later analysis.



* Left scale; ** Right scale.

Figure 3: The means of the variables in the ICR game.

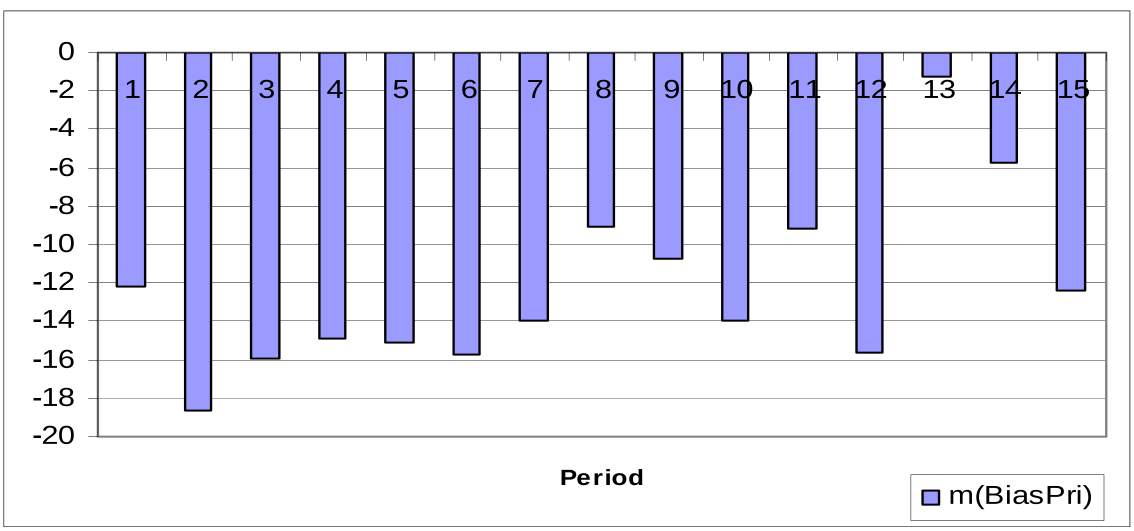
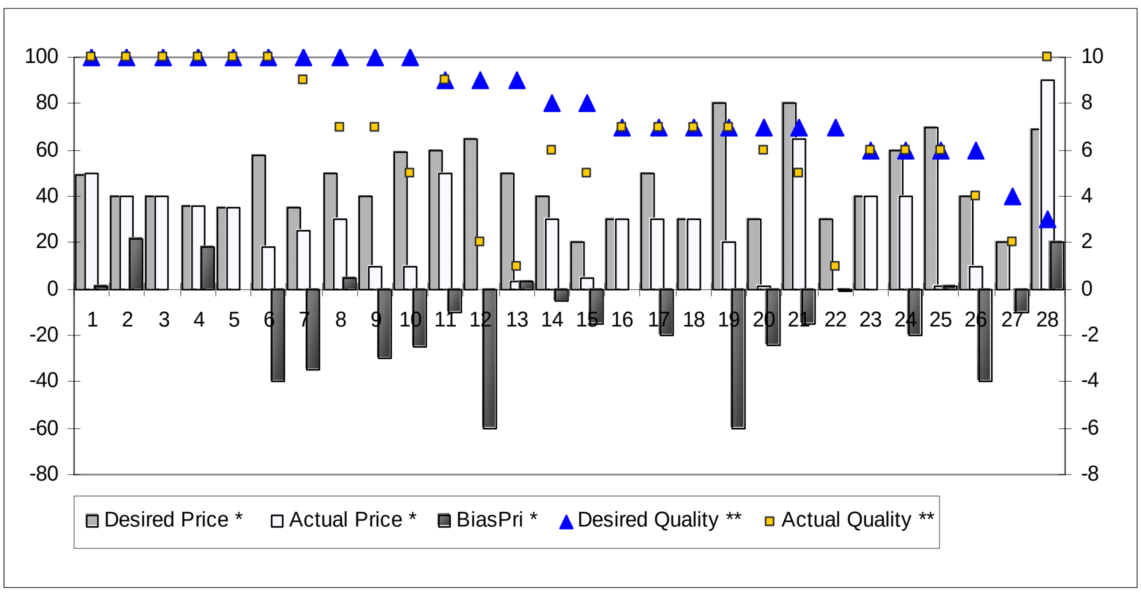


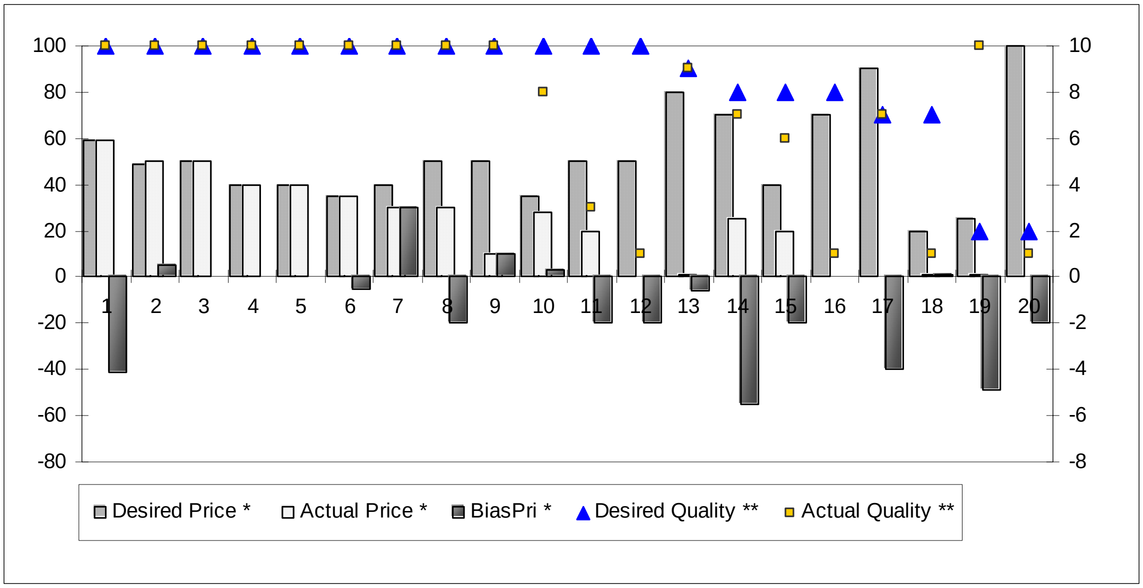
Figure 4: The mean of *BiasPri* for each period.

Next, I present data on when the sellers have a high likelihood of experiencing SSB. Figure 5 presents the values of p_D, p_A, q_D, q_A, and b_P from 28 contracts made in the first period after sorting them first by q_D, second by q_A, and third by p_A in descending order. In 5 out of the 14 contracts in which q_A is equal to q_D, SSB takes place (36%). On the other hand, for 10 out of 13 contracts in which q_A is less than q_D, SSB occurs (77%). Therefore, the likelihood that SSB occurs is greater in the case of $q_A < q_D$ than in the case of $q_A = q_D$. SSB does not occur in the one contract where $q_A > q_D$.



* Left scale; ** Right scale.

Figure 5: 28 contracts in the first period.



* Left scale; ** Right scale.

Figure 6: 20 contracts in the 15th period.

In the final period, for 5 out of 11 contracts in which q_A is the same as q_D, SSB occurs (45%). On the other hand, for 5 out of 8 contracts in which q_A is less than q_D, SSB occurs (63%).[38] Therefore, the likelihood that SSB occurs is greater in the case of $q_A < q_D$ than in the case of $q_A = q_D$.

Similar patterns also exist when I analyze the entire data set. In all periods, for 228 out of 386 contracts, SSB takes place (Table 5). For 72 out of 172 contracts where q_A is the same as q_D, SSB occurs (42%). For 131 out of 172 contracts in which q_A is less than q_D, SSB occurs (76%). For 25 out 42 contracts in which q_A is greater than q_D, SSB occurs (60%). These results imply that in the case of $q_A < q_D$, the buyers are more likely to set p_A below the sellers' expectation, p_E than in the other two cases. In the

[38] For one contract in which q_A is greater than q_D, SSB occurs.

one-sided test in which the null hypothesis is that the probabilities of SSB are the same in the two cases of $q_A < q_D$ and $q_A = q_D$ and the alternative hypothesis is that the probability is larger in the case of $q_A < q_D$ than in the case of $q_A = q_D$, the test statistic is $z = 6.468$ (p-value < 0.0001). In the one-sided test in which the null hypothesis is that the probabilities of SSB are the same in the two cases $q_A < q_D$ and $q_A > q_D$ and the alternative hypothesis is that the probability is larger in the case of $q_A < q_D$ than in the case of $q_A > q_D$, the test statistic is $z = 2.175$ (p-value = 0.0148).

	Number of Contracts (A)	Number of SSB (B)	B/A×100 (%)
$q_A = q_D$	172	72	42
$q_A < q_D$	172	131	76
$q_A > q_D$	42	25	60
Total	386	228	59

Table 5: Likelihood that SSB occurs.

15. 2. Sellers' Rejection Decision

In the next step of the analysis, a probit regression for the sellers' decision on rejection or acceptance of any offer is estimated and the impact of SSB on the decision is investigated. The results are presented in the first column of table 6. The binary dependent variable, *Reject* is 1 if the sellers do not accept any offer in a period and 0 otherwise. The independent variables include the sum of payoffs up to the previous contract (*Lag total* π_s), the payoff of the previous contract (*Lag* π_s), the number of contracts in which π_s is less than the reservation payoff of 10 up to the previous contract (*N. of* π_s *<10*), *BiasPri* in the previous contract (*LBP*), the sum of SSB experienced up to the previous contract (*Lag total SSB*), the seller's demographic and social preference variables, and experiment dummy variables.[39] *Lag total SSB* of the period $t = 2,\ldots,15$ is $\sum_{i=1}^{t-1} SSB_{(BiasPri_i<0)}$, where $SSB_{(BiasPri_i<0)}$ is equal to $BiasPri_i$ if $BiasPri_i < 0$ and 0 if $BiasPri_i \geq 0$ or no contract in the period *i*.

A higher *Lag total* π_s implies the seller had a better contracting experience with the buyers. I expect that as the sellers have better experiences, they are less willing to reject any given offer. If π_s was less than 10 in a contract, the seller would have been better off without a contract. So, I expect that as *N. of* π_s *<10* is larger, the sellers are more willing to reject any offer. The level of π_s in the previous contract could also affect the sellers' decision. As *Lag* π_s is greater, the seller may be less willing to reject any offer. The more negative *LBP* is, which implies greater SSB in the previous contract, the more the seller may be willing to reject any offer. The more negative *Lag total SSB* is, which implies a worse experience for the seller in her estimation of buyers' trustworthiness, the more the seller may be willing to reject any offer.

If some sellers did not accept an offer in a period for either of the following two cases, those observations are excluded from the data set. First, the other 5 sellers had already accepted offers prior to the seller. Second, the number of contracts made in any period was both the same as the number of offers and less than 5. In these two cases, it is

[39] For example, if the seller *i* made a contract in the period 3, experienced the *BiasPri* of -4, and did not accept any offer in the period 4, *LBP* is -4 in the period 5.

hard to tell whether the seller was actually unwilling to accept offers or the seller could not accept an offer although she was willing. The first observation for each seller is excluded since several lagged variables are used.

The signs of the coefficients of *Lag total* π_s, *Lag* π_s, and *N. of* π_s *<10* are consistent with my expectations and are significant. However, *LBP* and *Lag total SSB* are not significant. These results show that the sellers employ the history of payoffs in all past contracts as the main information for rejecting or accepting an offer rather than employing the history of SSB, although they had experienced SSB. That is, the psychological experience such as SSB may be crowded out by the economic experiences such as the payoffs of the past contracts and thus, seems to be ignored in the economic decision.

From figure 2, I know that as the ICR game goes on, the number of contracts per period decreases. This supports the claim that bargaining impasses take place more frequently as the ICR game goes on. The significances of the three variables relating to the sellers' payoffs imply that the main cause of these impasses is bad experience with low payoffs in past contracts rather than SSB. Among the 128 observations in which the sellers rejected offers, in only 2 observations were π_s of the previous contract greater than 10 and *BiasPri* of the previous contract negative, which is consistent with the above statement. This result is not consistent with the previous literature (Babcock et al., 1995; Babcock and Loewenstein, 1997) that shows that SSB is an important determinant of bargaining impasses.

	Rejection/ Acceptance[a]	Actual Quality[b]	Expected Price[b]	Actual Price[b]
	Coeff. (Sta. Dev.)	Coeff. (Sta. Dev.)	Coeff. (Sta. Dev.)	Coeff. (Sta. Dev.)
Lag total π_s	-0.007 ** (0.003)	0.003 * (0.001)	0.015 (0.023)	
Lag π_s	-0.039 ** (0.018)	0.022 ** (0.010)	0.078 (0.108)	
N. of $\pi_s < 10$	0.360 *** (0.109)	0.075 (0.115)	-2.183 ** (1.084)	
Lag total SSB	-0.003 (0.003)	0.008 *** (0.003)	0.036 (0.043)	
LBP	0.003 (0.007)	0.007 (0.007)	-0.107 (0.077)	
p_D		0.004 (0.009)	0.274 *** (0.073)	0.140 ** (0.069)
q_D		0.397 *** (0.082)		
DiffQual+			0.573 (1.487)	0.722 (1.331)
DiffQual-			-0.700 (0.464)	-1.592 ** (0.743)
q_A			2.943 *** (0.398)	1.865 ** (0.779)
BiasQual+				0.518 (0.976)
BiasQual-				-0.446 (1.159)
Lag total π_B				-0.090 * (0.053)
Lag π_B				0.004 (0.004)
Constant	-4.289 * (2.390)	3.317 *** (0.768)	7.749 (6.380)	9.878 * (5.718)
R^2	0.549	0.367	0.295	0.421
N	475	344	344	344
Log Pseudo Likelihood	-124.835	-	-	-
F-statistics	-	F(7, 297) = 20.960	F(9, 295) = 17.490	F(8, 306)= 30.02

a- Probit regression with robust standard errors. The sellers' demographic and social preference variables and experiment dummy variables are included, but not reported. [40]
b- Fixed effects models with robust standard errors.[41]
*** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

Table 6: Determinants of the variables in the ICR game.

[40] The coefficients from the random effects model are the same and the significances of the coefficients do not change much. I did not estimate the fixed effects model because of an incidental parameters problem that makes the maximum likelihood estimator inconsistent (Greene, 2003, Ch. 21).
[41] In the fixed effects model, u_{it}, where *i* indexes subjects and *t* indexes periods, called idiosyncratic errors are assumed to have a constant variance across *t* and are serially uncorrelated. However, the fixed effects model with robust standard errors allows u_{it} to have an arbitrary form (Wooldridge, 2002, Ch. 10).

However, prior experiments differ from the ICR game experiment in two aspects. First, in Babcock and Loewenstein's experiment subjects should negotiate and agree on the amount of a settlement, which a defendant pays to a plaintiff, as early as they can in order to reduce lawyers' fees and prevent legal fees. The lawyers' fees are charged when negotiation enters the next round and the legal fees are charged when no settlement is reached within 6 rounds. That is, whether to reach a settlement and the amount of that settlement are determined by unstructured negotiation between a plaintiff and a defendant. However, in the ICR game experiment, the sellers' rejection decision and *Actual Quality* decision are not made by negotiation but solely by the sellers' willingness. The level of *Actual Price,* which corresponds to the amount of a settlement in Babcock and Loewenstein's experiment, is also determined solely by the buyers and is not affected by *Expected Price* because negotiation is not possible and the buyers are not informed of the level of *Expected Price*. Second, in Babcock and Loewenstein's experiment, subjects were not informed of the size of SSB and played the bargaining game only once. In the ICR game experiment, the sellers were informed of the size of SSB and played for multiple periods. Therefore, in their experiment, whether SSB affects settlement rate and the amount of settelement within a current relationship can be analyzed, but the impact of SSB on behavioral decisions in the next relationship cannot be analyzed. On the other hand, in the ICR game experiment, the impact the potential SSB of a current period on the subjects' (i.e., sellers') behavior in a current period is not analyzed. Instead, whether experiencing SSB in a current period affects the sellers' decisions in future periods can be analyzed.

The results in the ICR game should not be interpreted as a counter-example to Babcock and Loewnestein's results because of the above differences. Instead, the results show that, the impact of SSB on subjects' behavior can differ drastically according to the structure of a game. The results also show that when subjects have information on both the history of payoffs and the history of SSB, subjects' behavior is more affected by the former than the later.

Result 1. SSB has no significant effect on the sellers' decision to reject or accept any offer.

Result 2. The history of payoffs has a significant effect on the sellers' decision to reject or accept any offer.

15. 3. Sellers' *Actual Quality* Decision

It is expected that SSB may play an important role in the seller's decision about the level of *Actual Quality*, which represents the seller's level of trust and determines the surplus of a contract. That is, if the sellers perceive that the buyers do not always act in the sellers' favor as much as the sellers expect, the sellers may reduce the levels of *Actual Quality* in order to reduce the maximum payoffs that the buyers would earn.

The second column of table 6 presents the results of the regression in which *Actual Quality*, q_A is the dependent variable. The independent variables include *Desired Price*, p_D and *Desired Quality*, q_D in addition to the variables included in the probit regression since the sellers know these at the point of deciding *Actual Quality*.

The sign of *Lag total* π_s is expected to be positive since the sellers with better experiences on the past contracts are willing to provide greater *Actual Quality* in the current contract. It is expected that greater *Lag* π_s and smaller *N. of* π_s *<10* will be related to greater *Actual Quality*. It is also expected that smaller *LBP* and *Lag total SSB* are related to smaller *Actual Quality*. The expected signs of *Desired Price* and *Desired Quality* are ambiguous. Since both are unenforceable, it is expected that they probably do not have significant effects on *Actual Quality*. On the other hand, if both fulfill the role of "cheap talk," both may affect *Actual Quality* positively. The first observation for each seller is excluded since several lagged variables are used.

The coefficients of *Lag total* π_s, *Lag* π_s, *Lag total SSB* and *Desired Quality* are significant and the signs of the coefficients of all variables are consistent with my expectations.[42] The positive signs of *Lag total* π_s and *Lag* π_s show that a good experience of all past contracts affects the seller's choice on *Actual Quality* in the current contract positively. The positive sign of *Lag total SSB* indicates that the larger sum of SSB the seller experienced in all past contracts, the more she reduces *Actual quality* in the current contract. Note that the value of *Lag total SSB* is non-positive by definition and a smaller *Lag total SSB* represents a larger sum of SSB in all past contracts. The fact that *Lag total SSB* is significant but *LBP* is not indicates that the seller considers the experience of the aggregated SSB in all past contracts rather than the experience of SSB in only the previous contract in deciding *Actual Quality*.

[42] The results from the fixed effects model are presented since the main interests are the coefficients of the variables obtained from the ICR game, which are time-varying.

These results show that the sellers employ both their histories of payoffs and histories of SSB in all past contracts in their decisions on *Actual quality,* unlike their decisions to reject or accept any offer. Bad experiences (i.e., SSB) relating to the discrepancies between the sellers' estimations of the buyers' trustworthiness and the buyers' actual trustworthiness reduce the sellers' trust. So, surplus from the contracts decreases. The maximum payoffs that the buyers earn also decrease. Thus, the buyers may reduce *Actual Price* and thus, the sellers' payoffs may decrease.[43] If a seller experiences a low enough payoff in a current contract, she is more likely to reject any given offer in the next period. Therefore, it may be concluded that SSB indirectly affects bargaining impasses.

Result 3. The seller's decision on Actual Quality is affected significantly by her experience with SSB in all past contracts.

While *Desired Quality* is significantly positive, *Desired Price* is positive but not significant. Therefore, sellers rely more on *Desired Quality* than on *Desired Price* when they decide *Actual Quality*. This result supports the idea that the level of *Desired Quality* plays the role of "cheap talk" in the sellers' choices of *Actual Quality,* although *Desired Quality* is not an enforceable commitment. I can argue that the seller's *Actual Quality* decision is affected by *Desired Quality,* which is information related to quality, but is not affected by *Desired Price*, which is not related to quality, since the seller just chooses *Actual Quality*. Moreover, I can argue that the sellers do not use *Desired Price* as reference information since they may think that the buyers' decision on *Actual Price*

[43] The relation between *Actual Quality* and *Actual Price* is analyzed in the later part of this chapter.

would depend on the sellers' *Actual Quality* more significantly than on buyers' *Desired Price*.

Result 4. The seller's decision on Actual Quality representing the seller's trust is affected by Desired Quality, which is unenforceable.

15. 4. Sellers' *Expected Price* Decision

In this section, the determinants of *Expected Price* are investigated, since *Expected Price* is one factor affecting the existence and size of SSB. Note that SSB exists when *Expected Price* is greater than *Actual Price*. The third column of table 6 presents the results of the fixed effects model that has *Expected Price* as the dependent variable. In addition to the variables employed in the regression of *Actual Quality*, *DiffQual+* and *DiffQual-* are included as independent variables.

A greater $N.\ of\ \pi_s < 10$ is related to a lower *Expected Price*, which implies that a bad experience with low payoffs in all past contracts decreases *Expected Price*. However, the relationships between the other two variables, $Lag\ total\, \pi_s$ and $Lag\, \pi_s$, relating to the sellers' payoffs and *Expected Price* are not significant. The two variables relating to SSB are not significant, which means that the existence of SSB in past contracts does not reduce the likelihood that the seller accepting an offer experiences SSB in the current contract. SSB exists when *Expected Price* is greater than *Actual Price*. Therefore, as *Expected Price* is smaller, the likelihood that *Expected Price* is greater than *Actual Price* decreases. The signs of *Desired Price*, *DiffQual+, DiffQual-,* and *Actual Quality* are sensible and the same as my expectations. The coefficients of *Desired Price* and *Actual Quality* are significant. Though the coefficient of *DiffQual-* is slightly insignificant at 10% level, we need to note the value of -0.700 for later analysis.[44] The coefficient (0.274) of *Desired Price* is positive and significant. This implies that for the same *Actual Quality*, the sellers expect the buyers to set higher *Actual Price* when *Desired Pric*e is higher, although the sellers do not consider *Desired Pric*e in deciding *Actual Quality*. Note that *Desired Price* is not significant in the regression in which *Actual Quality* is the dependent variable. While the sellers do not use *Desired Price* as reference information in deciding *Actual Quality*, they do in deciding *Expected Price*. This fact may be one cause of SSB. The sellers seem to have an information-selection bias.[45] *Actual Effort,* which decides the level of surplus from a contract, does not decide the seller's payoff directly. However, it is indirectly related to the seller's payoff, since the seller's payoff is likely to decrease as surplus from a contract is smaller. On the other hand, the sellers significantly consider *Desired Price* in their decision on *Expected Price,* which is related to the sellers' expectation of their payoffs. Although both decisions on *Actual Effort* and *Expected Price* are related to the sellers' payoffs, the sellers consider *Desired Price* only in the decision on *Expected Price* that is directly related to their payoffs.

For example, suppose that in a period, a seller *i* accepts an offer specifying *Desired Price* of 50 and *Desired Qualit*y of 5 and a seller *j* accepts an offer specifying *Desired Price* of 25 and *Desired Quality* of 5. Assume that the two sellers have the same

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[44] Later analysis on *Actual Price* shows that this variable is one of the main factors in causing and increasing SSB. In the fixed effects model where *Actual Price* is the dependent variable, the coefficient of *DiffQual-* is -1.592.

[45] This is somewhat similar to the notions that SSB results from selective information processing (Darley and Gross, 1983) and that SSB results from role-dependent evaluation of information (Babcock and Loewenstein, 1997).

experiences relating to payoffs and SSB in past contracts. The two sellers choose the same level of *Actual Quality* since the decision on *Actual Quality* is not significantly affected by *Desired Price*. However, the seller *i*'s *Expected Price* is greater than the seller *j*'s *Expected Price* since the decision on *Expected Price* is affected significantly by *Desired Price*. Then, the seller *i* has a greater likelihood of experiencing SSB than does seller *j*.

Result 5. The seller's decision on Expected Price is not affected by experience with SSB.

Result 6. While the seller's decision on Actual Quality is not affected by Desired Price, which is unenforceable, the seller's decision on Expected Price is significantly affected by Desired Price.

15. 5. Buyers' *Actual Price* Decision

In this section, the determinants of *Actual Price* are investigated since *Actual Price* is a factor determining the existence and size of SSB along with *Expected Price*. Note that SSB exists when *Actual Price* is less than *Expected Price*.

The fourth column of table 6 presents the results of the fixed effects model in which the dependent variable is *Actual Price*. The independent variables include the sum of the buyer's payoffs up to the previous contract (*Lag total* π_B) and the buyer's payoff in the previous contract (*Lag* π_B) together with other control variables shown in table 6.

The signs of the coefficients of *DiffQual+*, *DiffQual-*, *BiasQual+*, and *BiasQual-* make sense but only *DiffQual-* is significant. The positive coefficients of *DiffQual+* and *BiasQual+* suggest that buyers act reciprocally to some extent when *Actual Quality* is greater than either *Desired Quality* or *Expected Quality*. The coefficient (-1.592) of *DiffQual-* is smaller than the coefficient (-0.700) of *DiffQual-* in the regression where *Expected Price* is the dependent variable. When *Actual Quality* is smaller than *Desired Quality*, the impact of an increase in *DiffQual-* on *Actual Price* is greater than on *Expected Price*. Therefore, as *DiffQual-* is larger, the size of SSB is likely to be greater.

Result 7. As the difference between Actual Quality and Desired Quality (i.e., DiffQual-) increases, the size of SSB is likely to increase.

The coefficients (1.865 and 0.140) of *Actual Quality* and *Desired Price* are positive and significant. They are less than, respectively, the coefficient (2.943) of *Actual Quality* and the coefficient (0.274) of *Desired Price* in the fixed effects model in which *Expected Price* is the dependent variable. That the marginal effect of *Actual Quality* on *Expected Price* is greater than the marginal effect of it on *Actual Price* implies that the greater *Actual Quality* is, the greater SSB the sellers are likely to experience. That the marginal effect of *Desired Price* on *Expected Price* is greater than the marginal effect of it on *Actual Price* implies that the greater *Desired Price* is, the greater SSB the sellers are likely to experience. This result shows that although *Desired Price* is not enforced, it plays the role of “cheap talk” and the sellers consider *Desired Price* as more important reference information in their decision on *Expected Price* than the buyers do in their decision on *Actual Price*.

Result 8. As Desired Price increases, the size of SSB is likely to increase.

CHAPTER 16

CONCLUSION

I present an experiment that investigates the existence of SSB, the causes of SSB, and the effect of SSB on players' strategic behavior by examining a multi-period incomplete contracting game in which contract terms are unenforceable.

The data shows, first, that SSB exists in the aggregate. Second, there exists substantial heterogeneity in responses to an unenforceable contract term such as *Desired Price* and the difference between *Actual Quality* and *Desired Quality*. As a result, SSB is likely to take place and to increase as either *Desired Price* or the difference between *Actual Quality* and *Desired Quality* increases. Third, SSB has no significant direct effect on sellers' contract rejection decisions, but it does have a significant effect on *Actual Quality*, which can be interpreted as a measure of trust.

One implication of these results is that *Desired Price* plays the role of cheap talk and the sellers respond to it more drastically than the buyers who send it. *Desired Quality* also plays the role of cheap talk. While the sellers care only about their histories of payoffs in their rejection decisions, they consider their histories of SSB as well as their histories of payoffs in *Actual Quality* decisions. The results also allow us to discuss bargaining impasses, because a rejection of any offer by a seller can be thought of as a bargaining impasse since it results in zero surplus. The game theoretical solution of the ICR game explained in the chapter 13 implies that the rejection of an offer by a seller should take place even in the first period of the ICR game. The data of the ICR game shows that the experimental contracting market becomes gradually closer to the game theoretical solution as the ICR game goes on. There are two factors that induce this. The first is an economic factor relating to the history of payoffs, which has a direct impact on the rejection decision. When either the seller's aggregated payoffs for all past contracts is low, the seller' payoff for the previous contract is low, or the number of contracts in which the seller' payoff is less than the reservation payoff is great, the seller is less willing to make a contract in the current period. The second is a psychological factor relating to SSB. The reason why the sellers would choose high levels of *Actual Quality* is that they have trust and expect the buyers to have trustworthiness. However, when the buyers' actual trustworthiness, which is represented by *Actual Price*, is less than the sellers' estimation of it, which is represented by *Expected Price*, the sellers experience SSB. While the size of SSB does not significantly affect the sellers' rejection decisions, it is significantly and negatively related to the level of *Actual Quality*, which determines the level of surplus from a contract. That is, when the seller experiences large SSB, she tends to exert a low level of *Actual Quality*. Therefore, surplus from the contract decreases and the maximum payoff that the buyer earns also decreases. Thus, the buyer tends to reduce *Actual Price* so that the seller's payoff decreases. If the seller experiences a low enough level of payoff in a current contract, she may reject any given offer in the next period. Therefore, SSB affects indirectly the rejection decision.

The analyses of the ICR game allow disentangling economic factors from psychological factors such as SSB. The results suggest that economic factors, such as the histories of payoffs, are more important causes of bargaining impasses than psychological factors, such as SSB, but that SSB affects indirectly these impasses in a multi-period incomplete contracting game.

APPENDIX A

PROOFS OF REMARKS, COROLLARY, AND PROPOSITIONS IN ESSAY 1

***Proof of Remark 1**:* Suppose a contract that delivers payoffs (10) and (11), implements effort level *e,* is self-enforcing and optimal, and generates surplus $s = \pi + u$. I construct a stationary contract that implements e in every period and thus is optimal. My goal is to show that incentives provided through variations in continuation payoffs $\pi(a)$ and $u(a)$ can also be provided via changes in the discretionary payments. Thus, there would be no need to change the continuation equilibrium. Define stationary discretionary bonuses:

(A1) $$\dot{b}(a) \equiv b(a) + p\frac{\delta}{1-\delta}u(a) - p\frac{\delta}{1-\delta}u \text{ for all } a.$$

After substituting (A1) into (10) and rearranging, I can define the fixed payment:

(A2) $$\dot{w}^m = \frac{1-\delta p}{1-\delta}u - \frac{\delta - \delta p}{1-\delta}\tilde{u} - E_a[\dot{b}(a) \mid e] + c(e).$$

This is the level of fixed payment that will guarantee an expected per-period payoff equal to u. Therefore, I have the stationary contract $(\dot{w}^m, 0, \dot{b}(a), e, \pi, u)$, where

$$u \equiv \frac{1-\delta}{1-\delta p}E_a[\dot{w}^m + \dot{b}(a) - c(e) \mid e] + \frac{\delta - \delta p}{1-\delta p}\tilde{u} \text{ and}$$

$$\pi \equiv \frac{1-\delta}{1-\delta p}E_a[a - \dot{w}^m - \dot{b}(a) \mid e] + \frac{\delta - \delta p}{1-\delta p}\overline{\pi}.$$

If the principal deviates from the offer specified above or the parties renege on the discretionary payment, then the parties revert to a static equilibrium where $e = 0$.

To see whether this stationary contract is self-enforcing, note that, by assumption, $u \geq \overline{u}$ and $\pi \geq \overline{\pi}$. I can rearrange (A1) to get:

(A3) $$\dot{b}(a) + p\frac{\delta}{1-\delta}u \equiv b(a) + p\frac{\delta}{1-\delta}u(a) \qquad \forall a \in A.$$

Substituting (A3) into (iv*) produces $\dot{b}(a)+p\frac{\delta}{1-\delta}u \geq p\frac{\delta}{1-\delta}\tilde{u}$ for all a and this means that the discretionary payment constraint for the agent is satisfied in the stationary contract. Additionally, I can verify by substituting (A3) into the incentive-compatibility constraint (ii*) that the agent will choose the same effort level as he would under the original contract. Moreover, by Levin's (2003) Lemma 1, I can use the relationship $u+\pi \equiv u(a)+\pi(a)$ for all a, so I have from (A3):

$$(A4) -\dot{b}(a)+p\frac{\delta}{1-\delta}\pi \equiv -b(a)+p\frac{\delta}{1-\delta}\pi(a) \qquad \forall a \in A$$

Substituting (A4) into (iii*) produces $-\dot{b}(a)+p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\pi_{-G|x_G}$ for all a, which means that the discretionary payment constraint for the principal is satisfied under the stationary contract. Finally, note that since the stationary contract repeats in every period, the continuation contract is self-enforcing. Therefore, the stationary contract $(\dot{w}^m, 0, \dot{b}(a), e, \pi, u)$ is self-enforcing.

Proof of Remark 2: Suppose that there exists a self-enforcing stationary contract that promises the agent $u=\overline{u}$ and implements some $e>0$. Self-enforcement implies that, $\forall a \in A$, the discretionary payment constraints for both parties should be satisfied; that is, I have:

$$-b(a)+p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\pi \text{ and } b(a)+p\frac{\delta}{1-\delta}\overline{u} \geq p\frac{\delta}{1-\delta}\overline{u} \text{ for all } a.$$

From these two constraints, I can see that they are simultaneously satisfied only when $b(a) = 0 \;\; \forall a \in A$. Using the incentive-compatibility constraint, it is straightforward to verify that when $b(a) = 0$, then the agent will choose e = 0, which is a contradiction.

Proof of Proposition 1: A stationary contract $\left(w^m, w^s, b(a), e, \pi, u\right)$, where $w^s > 0$, is self-enforcing, if and only if the following constraints are satisfied:

(A5) $$\pi = \frac{1-\delta}{1-\delta p}\left\{\int\left(a-b(a)\right)f(a \mid e)da - w^m\right\} + \frac{\delta-\delta p}{1-\delta p}\left(\overline{\pi}-(1-\delta)w^s\right) \geq \overline{\pi}$$

(Participation constraint for P)

(A6) $$u = \frac{1-\delta}{1-\delta p}\left\{w^m + \int b(a)f(a \mid e)da - c(e)\right\} + \frac{\delta-\delta p}{1-\delta p}\left(\widetilde{u}+(1-\delta)w^s\right) \geq \overline{u}$$

(Participation constraint for A)

(A7) $$e = \arg\max_{\widetilde{e}} \int b(a)f(a \mid \widetilde{e})da - c(\widetilde{e})$$ (IC)

(A8) $$-\sup_a b(a) + p\frac{\delta}{1-\delta}\pi \geq p\left\{\frac{\delta}{1-\delta}\pi - \delta w^s\right\}$$ (Discretionary payment constraint for P)

(A9) $$\inf_a b(a) + p\frac{\delta}{1-\delta}u \geq p\left\{\frac{\delta}{1-\delta}\widetilde{u} + \delta w^s\right\}$$ (Discretionary payment constraint for A)

I will now construct a self-enforcing stationary contract without a severance payment that implements the same e and delivers the same expected per-period payoffs. Adding (subtracting) $\delta p w^s$ to (from) both sides of discretionary payment constraints for P (A) and setting $\dot{b}(a) = b(a) - \delta p w^s$ for all a yields $-\sup_a \dot{b}(a) + p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\pi$ and $\inf_a \dot{b}(a) + p\frac{\delta}{1-\delta}u \geq p\frac{\delta}{1-\delta}\widetilde{u}$. Thus, the discretionary payment constraints are satisfied for the new bonus schedule $\dot{b}(a)$. Now define a new base payment, $\dot{w}^m = w^m + \delta w^s$. Solving for w^m and substituting $w^m = \dot{w}^m - \delta w^s$ and $b(a) = \dot{b}(a) + \delta p w^s$ into (A5)-(A7) produces:

(A10) $\pi = \frac{1-\delta}{1-\delta p}\left\{\int \left(a - \dot{b}(a)\right) f(a \mid e) da - \dot{w}^m\right\} + \frac{\delta - \delta p}{1-\delta p}\bar{\pi} \geq \bar{\pi}$,

(A11) $u = \frac{1-\delta}{1-\delta p}\left\{\dot{w}^m + \int \dot{b}(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p}{1-\delta p}\tilde{u} \geq \bar{u}$, and

(A12) $e \in \arg\max_{\tilde{e}} \int \dot{b}(a) f(a \mid \tilde{e}) da - c(\tilde{e}) + \delta p w^s$.

Therefore, a contract that replaces w^m and $b(a)$ with $\dot{w}^m$ and $\dot{b}(a)$ satisfies all constraints for self-enforcement. Thus, the self-enforcing stationary contract $(w^m + \delta w^s, 0, b(a) - \delta p w^s, e, \pi, u)$ implements the same effort e and gives both parties the same expected per-period payoffs.

Proof of Remark 3: Since the severance payment is zero ($w^s = 0$), I know from the discretionary payment constraint for the principal that $-\sup_a b(a) + p\frac{\delta}{1-\delta}\pi \geq p\frac{\delta}{1-\delta}\bar{\pi}$, which is satisfied if and only if $\sup_a b(a) \leq 0$. Also, I conclude from the agent's discretionary payment constraint that $\inf_a b(a) + p\frac{\delta}{1-\delta}u \geq p\frac{\delta}{1-\delta}\tilde{u}$, which is equivalent to $\inf_a b(a) \geq -\frac{p\delta}{1-\delta}(u - \tilde{u})$.

Proof of Proposition 2: The optimal contract characterized in proposition 2 can be derived by solving the principal's contract design problem. Denoting the multipliers of the agent's participation and incentive-compatibility constraints by λ_1 and λ_2, respectively, and the multipliers of the first and second inequalities in the double-sided boundary constraints by $\mu(a)$ and $\psi(a)$, respectively, I can write the Lagrangian L of (P2) as:

$$L(u,e,b(a),\lambda_1,\lambda_2,\mu(a),\psi(a)) = \frac{1-\delta}{1-\delta p}\left\{\int af(a\mid e)da - c(e)\right\} + \frac{\delta-\delta p}{1-\delta p}\overline{\pi} - u + \frac{\delta-\delta p}{1-\delta p}\widetilde{u}$$
$$+\lambda_1[u-\overline{u}] + \lambda_2\left[\int b(a)f_e(a\mid e)da - c_e(e)\right] - \int \mu(a)b(a)da + \int \psi(a)\left\{b(a)+\frac{p\delta}{1-\delta}(u-\widetilde{u})\right\}da$$

The first-order conditions are:

(A13) $\dfrac{dL}{de} = \dfrac{1-\delta}{1-\delta p}\left\{\int af_e(a\mid e)da - c_e(e)\right\} + \lambda_2\left[\int b(a)f_{ee}(a\mid e)da - c_{ee}(e)\right] = 0$

(A14) $\dfrac{dL}{du} = -1 + \lambda_1 + \dfrac{p\delta}{1-\delta}\int \psi(a)da = 0$

(A15) $\dfrac{dL}{db(a)} = \lambda_2 f_e(a\mid e) - \mu(a) + \psi(a) = 0$ for $\forall a \in A$

(A16) $\lambda_1[u-\overline{u}] = 0$; $\lambda_1 \geq 0$; $u-\overline{u} \geq 0$

(A17) $-\mu(a)b(a) = 0$; $\mu(a) \geq 0$; $b(a) \leq 0$ for $\forall a \in A$

(A18) $\psi(a)\left[b(a)+\dfrac{p\delta}{1-\delta}(u-\widetilde{u})\right] = 0$; $\psi(a) \geq 0$; $b(a)+\dfrac{p\delta}{1-\delta}(u-\widetilde{u}) \geq 0$ for $\forall a \in A$.

I will now establish the optimal contractual forms outlined in Proposition 2 by checking all Kuhn-Tucker cases.

I begin by examining the case when $\lambda_1 = 0$ (the agent's participation constraint does not bind). This is a sufficient condition for the bonus schedule to take the values, $b(a)$=0 or $b(a)=-\frac{p\delta}{1-\delta}(u-\tilde{u})$ for some $a \in A$. To see this, note from (A14) that $\int \psi(a)da = \frac{1-\delta}{p\delta} > 0$ so that $\psi(a)$ must be positive for some $a \in A$. Therefore, (A18) implies that $b(a)=-\frac{p\delta}{1-\delta}(u-\tilde{u})$ for some $a \in A$. Integrating (A15) over *a* yields:

(A19) $\lambda_2 \int f_e(a \mid e)da = \int \mu(a)da - \int \psi(a)da$

Since $\int f_e(a \mid e)da = 0$, I have $\int \mu(a)da - \int \psi(a)da = 0$ so that $\int \mu(a)da = \frac{1-\delta}{p\delta} > 0$.

Hence, $\mu(a)$ must be positive for some $a \in A$. Therefore, $b(a)$=0 for some $a \in A$.

Now suppose $\lambda_2 = 0$ in addition to $\lambda_1 = 0$.[46] In addition to the conditions outlined in the previous paragraph, I also have, from (A13), that,

(A20) $\int af_e(a \mid e)da - c_e(e) = 0$.

The effort level that is consistent with (A20) is equal to the first best effort level, e^{FB}, since (A20) is the first-order condition of the following objective function,

(A21) $\max_e \frac{1-\delta}{1-\delta p}\left\{\int af(a \mid e)da - c(e)\right\} + \frac{\delta-\delta p}{1-\delta p}\bar{\pi} + \frac{\delta-\delta p}{1-\delta p}\tilde{u}$

[46] If the Lagrangian multiplier of any equality constraint (i.e., the incentive compatibility constraint) is zero in an optimal solution, it means that the maximized value of objective function (i.e., the principal's expected per-period payoff) is not affected by such a constraint. That is, the maximized value of the objective function does not change if such a constraint is excluded from the optimization problem. In the latter part of this proof, one can see that when the first best effort is implemented in an optimal contract, λ_2 is zero.

, which maximizes the sum of both parties' expected per-period payoffs. However, I have from (A15) that $-\mu(a)+\psi(a)=0 \;\; \forall a \in A$, which implies that $\mu(a)=\psi(a)=0$ since $\mu(a)$ and $\psi(a)$ cannot be positive simultaneously. But $\mu(a)=\psi(a)=0 \;\; \forall a \in A$ contradicts $\int \mu(a)da = \int \psi(a)da = \frac{1-\delta}{p\delta} > 0$ which is implied by $\lambda_1 = 0$. Therefore, the case where $\lambda_1 = 0 \; and \, \lambda_2 = 0$ can be eliminated from consideration.

Now suppose $\lambda_2 > 0$ in addition to $\lambda_1 = 0$. Since $\int b(a) f_{ee}(a \mid e)da - c_{ee}(e) < 0$ should be satisfied when evaluated at an optimal e, I know from (A13) that $\int a f_e(a \mid e)da - c_e(e) > 0$ at an optimal *e*. Moreover, by the assumptions of MRLP, CDFC, and the convexity of the effort cost function, $\int af(a \mid e)da - c(e)$ must be concave so that $e < e^{FB}$. I also examine three sub-cases where either $\mu(a) > 0$ and $\psi(a) = 0$, $\mu(a) = 0$ and $\psi(a) > 0$, or $\mu(a) = 0$ and $\psi(a) = 0$. From (A15), if $\mu(a) > 0$ and $\psi(a) = 0$ for some $a \in A$ then $f_e(a \mid e) > 0$ and it follows from (A17) that $b(a) = 0$. If $\mu(a) = 0$ and $\psi(a) > 0$ for some $a \in A$, then I have from (A15) that $f_e(a \mid e) < 0$ and it follows from (A18) that $b(a) = -\frac{p\delta}{1-\delta}(u - \tilde{u})$. If $\mu(a) = 0$ and $\psi(a) = 0$ for some $a \in A$, then it follows from (A15) that $f_e(a \mid e) = 0$. Hence, $b(a)$ can be any value between 0 and $-\frac{p\delta}{1-\delta}(u - \tilde{u})$ but I set it to zero arbitrarily. Now let $\hat{a}$ be such that $f_e(\hat{a} \mid e)/f(\hat{a} \mid e) = 0$. Since $f_e(a \mid e)/f(a \mid e)$ is increasing in *a* by MLRP, $f_e(a \mid e) > 0$ for all $a > \hat{a}$ and $f_e(a \mid e) < 0$ for all $a < \hat{a}$. Therefore, the bonus schedule is "one-step" in that $b(a) = 0$ for all $a \geq \hat{a}$, $b(a) = -\frac{p\delta}{1-\delta}(u - \tilde{u})$ for all $a < \hat{a}$. This establishes that whenever the agent's participation constraint does not bind, the optimal contract is a one-step contract, and implements some effort level $e < e^{FB}$.

Finally, I check the case where $\lambda_2 < 0$ in addition to $\lambda_1 = 0$. Since $\int b(a) f_{ee}(a \mid e) da - c_{ee}(e) < 0$ at an optimal e, I know from (A13) that $\int a f_e(a \mid e) da - c_e(e) < 0$ at an optimal e, which implies that $e > e^{FB}$. Using a sequence of steps similar to those used in the case where $\lambda_1 = 0$ and $\lambda_2 > 0$, I can derive the bonus schedule to be $b(a) = -\frac{p\delta}{1-\delta}(u - \tilde{u})$ for all $a > \hat{a}$ and $b(a) = 0$ for all $a \leq \hat{a}$. However, under this bonus schedule, any positive effort level cannot satisfy the incentive compatibility constraint since the first term of (ii) in (P2) is always negative and $c_e(e)$ is positive for all $e > 0$. I therefore rule out this case.

To summarize, I have shown part (i) of Proposition 2 to be true by analyzing all cases involving $\lambda_1 = 0$ (a contract promises u greater than $\bar{u}$). I will now establish part (ii) of the proposition by focusing on all cases where $\lambda_1 > 0$ (the agent's participation constraint binds).

Suppose that $\lambda_1 > 0$. If $\lambda_1 > 1$, then (A14) implies that $\frac{p\delta}{1-\delta}\int \psi(a) da = 1 - \lambda_1 < 0$. However, this is impossible, since $\psi(a)$ should be non-negative for all *a,* which implies that $\frac{p\delta}{1-\delta}\int \psi(a) da$ should be non-negative. Therefore, this case is ruled out.

On the other hand, if $0<\lambda_1<1$, then (A14) implies that $\int \psi(a)da=(1-\lambda_1)\frac{1-\delta}{p\delta}>0$. Following the logic used to analyze the case where of $\lambda_1=0$, $\psi(a)$ must be positive and $b(a)=-\frac{p\delta}{1-\delta}(u-\tilde{u})$ for at least one $a\in A$. Also, I know from (A15) and (A19) that $\int \mu(a)da-\int \psi(a)da=0$, which implies that $\int \mu(a)da>0$. Therefore, $\mu(a)$ >0 which implies that $b(a)=0$ for at least one $a\in A$. Following the same logic as that used for the case where $\lambda_1=0$, I can exclude the case where $\lambda_2\leq 0$, and show that, when $\lambda_2>0$, some $e<e^{FB}$ can be implemented by the one-step bonus schedule where $b(a)=0$ for all $a\geq \hat{a}$ and $b(a)=-\frac{p\delta}{1-\delta}(\bar{u}-\tilde{u})$ for all $a<\hat{a}$. This establishes the optimal contract when the participation constraint is binding which proves part (ii) of proposition 2.

To establish part (iii) of proposition 2, consider the case where $\lambda_1=1$. I have from (A14) that $\frac{p\delta}{1-\delta}\int \psi(a)da=0$, which implies that $\psi(a)$=0 $\forall a\in A$. By (A19), $\int \mu(a)da=0$, which suggests that $\mu(a)$=0 $\forall a\in A$. Therefore, $b(a)$ might be any value between 0 and $-\frac{p\delta}{1-\delta}(\bar{u}-\tilde{u})$ $\forall a\in A$. I have from (A15) that $\lambda_2 f_e(a\mid e)=0$ $\forall a\in A$, which implies that $\lambda_2=0$. Therefore, $e=e^{FB}$ is implied by (A13). Moreover, any monotone bonus schedule satisfying the incentive compatibility constraint $\int b(a)f_e(a\mid e^{FB})da-c_e(e^{FB})=0$ and $-\frac{p\delta}{1-\delta}(\bar{u}-\tilde{u})\leq b(a)\leq 0$ $\forall a\in A$ can be a solution.

The monotonicity of bonus schedule guarantees strict concavity of $\int b(a)f(a \mid e)da - c(e)$ in the incentive compatibility constraint in (P1). To show this, using integration by parts, I can rewrite $\int b(a)f(a \mid e)da - c(e)$ as follows:

(A22) $$\int b(a)f(a \mid e)da - c(e) = \left[b(a)F(a \mid e)\right]_{\underline{a}}^{\bar{a}} - \int_{\underline{a}}^{\bar{a}} \frac{db(a)}{da} F(a \mid e)da - c(e)$$

$$= b(\bar{a}) - \int_{\underline{a}}^{\bar{a}} \frac{db(a)}{da} F(a \mid e)da - c(e)$$

where the second line uses the fact $F(\underline{a} \mid e) = 0$ and $F(\bar{a} \mid e) = 1 \; \forall e \in \mathrm{E}$. Since $c_{ee}(e) > 0$ and $F_{ee}(a \mid e) > 0$ by CDFC, (A22) is strictly concave so long as $\frac{db(a)}{da} \geq 0$.

By this property, I know that the level of effort that satisfies $\int b(a)f_e(a \mid e)da - c_e(e) = 0$ in (P2) is globally optimal in the agent's optimization problem. In addition, Levin (1999) shows in his proof of his Proposition 1.4 that if a non-monotone bonus schedule yields a certain level of surplus, there always exists a monotone bonus schedule that yields at least as much surplus. Therefore, in this specific case, if a non-monotone bonus schedule can implement e^{FB}, there exists a monotone bonus schedule that implements e^{FB}. Finally, I can also show that a one-step bonus schedule can also qualify as a solution under certain conditions. When $b(a)$ is set to zero for all $a \geq \hat{a}$ and $b(a)$ is denoted by $\underline{b}$ for all $a < \hat{a}$ in the one-step bonus schedule, the incentive compatibility constraint,

$\underline{b}\int_{\underline{a}}^{\hat{a}} f_e(a \mid e^{FB})da + 0 \cdot \int_{\hat{a}}^{\bar{a}} f_e(a \mid e^{FB})da - c_e(e^{FB}) = 0$ can be rewritten as

$\underline{b}F_e(\hat{a} \mid e^{FB}) - c_e(e^{FB}) = 0$. Then, I have $b(a) = \underline{b} = \frac{c_e(e^{FB})}{F_e(\hat{a} \mid e^{FB})}$, $\forall a < \hat{a}$. If $\frac{c_e(e^{FB})}{F_e(\hat{a} \mid e^{FB})} \geq$

$-\frac{p\delta}{1-\delta}(\overline{u}-\widetilde{u})$, then this can be an optimal bonus schedule. This establishes part (iii) of proposition 2.

Proof of Proposition 3: The contract $(w^m, 0, b(a), e, \pi, u)$ is derived by solving the principal's contract design problem of (P1). When any positive severance payment w^s is imposed on the contract by regulation, the principal faces the following new contract design problem:[47]

$$\text{(AP1)}\ \max_{\hat{w}^m, \hat{b}(a), \hat{e}} \hat{\pi} = \frac{1-\delta}{1-\delta p}\left\{\int \left(a-\hat{b}(a)\right) f(a \mid \hat{e}) da - \hat{w}^m\right\} + \frac{\delta-\delta p}{1-\delta p}\left(\overline{\pi}-(1-\delta)w^s\right)$$

$$\text{s.t. } \hat{u} = \frac{1-\delta}{1-\delta p}\left\{\hat{w}^m + \int \hat{b}(a) f(a \mid \hat{e}) da - c(\hat{e})\right\} + \frac{\delta-\delta p}{1-\delta p}\left(\widetilde{u}+(1-\delta)w^s\right) \geq \overline{u}$$

(Participation constraint for A)

$$\hat{e} = \arg\max_{\widetilde{e}} \int b(a) f(a \mid \widetilde{e}) da - c(\widetilde{e}) \qquad \text{(IC)}$$

$$-\sup_a \hat{b}(a) + p\frac{\delta}{1-\delta}\hat{\pi} \geq p\left\{\frac{\delta}{1-\delta}\overline{\pi} - \delta w^s\right\} \quad \text{(Discretionary payment constraint for P)}$$

$$\inf_a \hat{b}(a) + p\frac{\delta}{1-\delta}\hat{u} \geq p\left\{\frac{\delta}{1-\delta}\widetilde{u} + \delta w^s\right\} \quad \text{(Discretionary payment constraint for A)}$$

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[47] The principal's objective function and the agent's participation constraint can be obtained the following recursive equation under the positive severance payments:

$\hat{u} \equiv (1-\delta)\left\{\hat{w}^m + \int \hat{b}(a) f(a \mid \hat{e}) da - c(\hat{e})\right\} + \delta\left\{p\hat{u} + (1-p)(\widetilde{u}+(1-\delta)w^s)\right\}$ and

$\hat{\pi} \equiv (1-\delta)\left\{\int \left(a-\hat{b}(a)\right) f(a \mid \hat{e}) da - \hat{w}^m\right\} + \delta\left\{p\hat{\pi} + (1-p)(\overline{\pi}-(1-\delta)w^s)\right\}$.

Discretionary payment constraints for both parties under the positive severance payments can be obtained by deleting common terms from:

$-\hat{b}(a) + p\frac{\delta}{1-\delta}\hat{\pi} + (1-p)\left\{\frac{\delta}{1-\delta}\overline{\pi} - \delta w^s\right\} \geq p\left\{\frac{\delta}{1-\delta}\overline{\pi} - \delta w^s\right\} + (1-p)\left\{\frac{\delta}{1-\delta}\overline{\pi} - \delta w^s\right\}$ and

$\hat{b}(a) + p\frac{\delta}{1-\delta}\hat{u} + (1-p)\left\{\frac{\delta}{1-\delta}\widetilde{u} + \delta w^s\right\} \geq p\left\{\frac{\delta}{1-\delta}\widetilde{u} + \delta w^s\right\} + (1-p)\left\{\frac{\delta}{1-\delta}\widetilde{u} + \delta w^s\right\}$.

, where $\hat{w}^m, \hat{b}(a)$, $\hat{e}, \hat{\pi}$ and $\hat{u}$ are used to distinguish (AP1) from (P1). An optimal contract from (AP1) is denoted by $(\hat{w}^m, w^s, \hat{b}(a), \hat{e}, \hat{\pi}, \hat{u})$. (AP1) can be rewritten as:

(AP1') $\max_{\hat{w}^m, \hat{b}(a), \hat{e}} \hat{\pi} = \frac{1-\delta}{1-\delta p}\left\{\int\left(a - \hat{b}(a) + \delta p w^s\right) f(a \mid \hat{e}) da - \hat{w}^m - \delta w^s\right\} + \frac{\delta - \delta p}{1-\delta p}\overline{\pi}$

$$\text{s.t. } \hat{u} = \frac{1-\delta}{1-\delta p}\left\{\hat{w}^m + \delta w^s + \int\left(\hat{b}(a) - \delta p w^s\right) f(a \mid \hat{e}) da - c(\hat{e})\right\} + \frac{\delta - \delta p}{1-\delta p}\widetilde{u} \geq \overline{u}$$

(Participation constraint for A)

$$\hat{e} = \arg\max_{\widetilde{e}} \int \hat{b}(a) f(a \mid \widetilde{e}) da - c(\widetilde{e}) \qquad \text{(IC)}$$

$$-\sup_a \hat{b}(a) + \delta p w^s + p\frac{\delta}{1-\delta}\hat{\pi} \geq p\frac{\delta}{1-\delta}\hat{\pi} \quad \text{(Discretionary payment constraint for P)}$$

$$\inf_a \hat{b}(a) - \delta p w^s + p\frac{\delta}{1-\delta}\hat{u} \geq p\frac{\delta}{1-\delta}\widetilde{u} \quad \text{(Discretionary payment constraint for A)}$$

Since (AP1) and (AP1') are actually equivalent, an optimal contract from (AP1') is also $(\hat{w}^m, w^s, \hat{b}(a), \hat{e}, \hat{\pi}, \hat{u})$.

I define $\hat{\hat{b}}(a) \equiv \hat{b}(a) - \delta p w^s$ for $\forall a \in A$ and $\hat{\hat{w}}^m \equiv \hat{w}^m + \delta w^s$. Then, $(\hat{w}^m, w^s, \hat{b}(a), \hat{e}, \hat{\pi}, \hat{u})$ can be rewritten as $(\hat{\hat{w}}^m - \delta w^s, w^s, \hat{\hat{b}}(a) + \delta p w^s, \hat{e}, \hat{\pi}, \hat{u})$.

Next, (AP1') can be rewritten as:

(AP1'') $\max_{\hat{\hat{w}}^m, \hat{\hat{b}}(a), \hat{e}} \hat{\pi} = \frac{1-\delta}{1-\delta p}\left\{\int\left(a - \hat{\hat{b}}(a)\right) f(a \mid \hat{e}) da - \hat{\hat{w}}^m\right\} + \frac{\delta - \delta p}{1-\delta p}\overline{\pi}$

$$\text{s.t. } \hat{u} = \frac{1-\delta}{1-\delta p}\left\{\hat{\hat{w}}^m + \int \hat{\hat{b}}(a) f(a \mid \hat{e}) da - c(\hat{e})\right\} + \frac{\delta - \delta p}{1-\delta p}\widetilde{u} \geq \overline{u}$$

(Participation constraint for A)

$$\hat{e} = \arg\max_{\tilde{e}} \int \hat{\hat{b}}(a) f(a \mid \tilde{e}) da - c(\tilde{e}) \qquad \text{(IC)}^{48}$$

$$-\sup_a \hat{\hat{b}}(a) + p\frac{\delta}{1-\delta}\hat{\pi} \geq p\frac{\delta}{1-\delta}\hat{\pi} \qquad \text{(Discretionary payment constraint for P)}$$

$$\inf_a \hat{\hat{b}}(a) + p\frac{\delta}{1-\delta}\hat{u} \geq p\frac{\delta}{1-\delta}\tilde{u} \qquad \text{(Discretionary payment constraint for A)}$$

Since (AP1") is equivalent to (P1), it is obtained that $b(a) = \hat{\hat{b}}(a)$ for $\forall a \in A$, $w^m = \hat{\hat{w}}^m$, $e = \hat{e}$, $\pi = \hat{\pi}$, and $u = \hat{u}$. Thus, $(\hat{\hat{w}}^m - \delta w^s, w^s, \hat{\hat{b}}(a) + \delta p w^s, \hat{e}, \hat{\pi}, \hat{u})$ representing an optimal contract from (AP1) is equivalent to $(w^m - \delta w^s, w^s, b(a) + \delta p w^s, e, \pi, u)$.

Proof of Proposition 4: Suppose that an optimal contract that is derived in (P1) takes the second form of proposition 2: the agent's expected per-period payoff is $u_S = \bar{u}$, an optimal effort is $e_S < e^{FB}$, and a bonus schedule is one-step such that $b(a) = 0$ for all $a \geq \hat{a}$ and $b(a) = -\frac{p\delta}{1-\delta}(\bar{u} - \tilde{u})$ for all $a < \hat{a}$. In the principal's contract design problem, (P3), the (DE_{AS}) constraint is:

(A23) $\frac{p_A \delta}{1-\delta}(u - \tilde{u}) \geq \sup_a b(a) - \inf_a b(a)$.

When $u_S = \bar{u}$ is in the optimal contract from (P1), one can know that the Lagrangian multiplier, λ_1 of the agent' participation constraint is positive and $\partial L / \partial \bar{u} = -\lambda_1 < 0$ from the proof of proposition 2. This implies that for given *p*, the principal wants to reduce u_S below $\bar{u}$ but cannot do because of the agent' participation constraint. Hence, there is no

[48] I omit the term $\delta p w^s$ since it is constant and it does not affect the agent's choice of effort.

reason that for $p_A > p$, the principal gives any rents to the agent in any optimal contract from (P3) since the principal can employ more variation in a bonus schedule due to $p_A > p$, which comes from the assumptions of $|p_P - p| < |p_A - p|$ and $p_P < p_A$. Hence, the agent's participation constraint is binding (i.e., $u = \overline{u}$) in any optimal contract from (P3). Then, I have the following (DE$_{AS}$) constraint:

(A24) $\frac{p_A \delta}{1-\delta}(\overline{u} - \widetilde{u}) \geq \sup_a b(a) - \inf_a b(a)$.

The left hand side (LHS) of (A24) is greater than that of (12) having $u = \overline{u}$.

(A24) can be either binding or nonbinding in an optimal contract from (P3). First, consider the case that (A24) is binding in an optimal contract from (P3). If p_A is not large enough compared to *p*, an allowable variation in a bonus schedule is still limited by LHS of (A24). From Propositions 2, a bonus schedule is one-step: $b(a) = 0$ for all $a \geq \hat{a}$ and $b(a) = -\frac{p_A \delta}{1-\delta}(\overline{u} - \widetilde{u})$ for all $a < \hat{a}$.[49] Under the above one-step bonus schedule, the incentive compatibility constraint of (P3) becomes

$e = \arg\max_{\widetilde{e}} -\frac{p_A \delta}{1-\delta}(\overline{u} - \widetilde{u}) F(\hat{a} \mid \widetilde{e}) - c(\widetilde{e})$. The first order condition is

$-\frac{p_A \delta}{1-\delta}(\overline{u} - \widetilde{u}) F_e(\hat{a} \mid e) - c_e(e) = 0$. Since

$\frac{de}{dp_A} = -\frac{\delta}{1-\delta}(\overline{u} - \widetilde{u}) F_e(\hat{a} \mid e) \Big/ \left\{ \frac{p_A \delta}{1-\delta}(\overline{u} - \widetilde{u}) F_{ee}(\hat{a} \mid e) + c_{ee}(e) \right\} > 0$ by the implicit function theorem, an effort level that the agent chooses in an optimal contract increases

[49] The constraints of (P3) are the same as those of (P1) except that *p* of (P1) changes to p_A in (P3). Therefore, the property that a bonus schedule is always one-step when the (DE) constraint is binding is not affected by asymmetric information on an exogenous shock. Therefore, I do not provide similar proof here.

as the probability of good state increases. Therefore, an optimal effort, e_{AS} is greater than e_S due to $p_A > p$.

Second, consider the case that (A24) is unbinding in an optimal contract from (P3). That is, if p_A is large enough compared to *p*, the variation in a bonus schedule that is necessary to implement e^{FB} is not limited by LHS of (A24). Then, e_{AS} is equal to e^{FB}. This case corresponds to part (iii) of proposition 2. For this, refer to the proof of part (iii) of proposition 2 in which Lagrangian multipliers of double side bonus constraints, $\psi(a)$ and $\mu(a)$ are zero for $\forall a \in A$. This implies that the (DE) constraint is not binding. Hence, e^{FB} is implemented so e_{AS} is greater than e_S.

Proof of Proposition 5: In the proof of proposition 4, it is stated that when u_S is equal to $\bar{u}$ in an optimal contract under symmetric information on an exogenous shock, the agent's participation constraint of (P3) is also binding in an optimal contract under asymmetric information on an exogenous shock. This implies that the agent's expected per-period payoff, $u_F = \frac{1-\delta}{1-\delta p_A}\left\{w^m + \int b(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p_A}{1-\delta p_A}\tilde{u}$ that the agent recognizes in an optimal contract from (P3) is equal to $\bar{u}$. The subscript *F* implies that the agent's recognition is false. However, the agent's true expected per-period payoff $u_{AS} = \frac{1-\delta}{1-\delta p}\left\{w^m + \int b(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p}{1-\delta p}\tilde{u}$ is less than $u_F = \bar{u}$ because of $p < p_A$.

Proof of Corollary 1: First, consider the case that in an optimal contract under symmetric information on an exogenous shock, e_S is less than e^{FB}. Since $e_{AS} > e_S$ by proposition 4, the expected per-period surplus from a contractual relationship also increases (i.e., $s(e_{AS}) > s(e_S)$). Since $u_{AS} < u_S$ by proposition 5, π_{AS} is greater than π_S. That is, $\pi_{AS} = s(e_{AS}) - u_{AS}$ is greater than $\pi_S = s(e_S) - u_S$ because of the two reasons: first, $s(e_{AS}) > s(e_S)$ due to $e_{AS} > e_S$ and second, $u_{AS} < u_S = \bar{u}$.

Second, consider the case that in an optimal contract under asymmetric information on an exogenous shock, e_S is equal to e^{FB}. Then, e_{AS} is equal to e^{FB} so $s(e_{AS})$ is equal to $s(e_S)$. Since $u_{AS} < u_S$ by proposition 5 and $s(e_{AS}) = s(e_S)$, π_{AS} is greater than π_S. That is, $\pi_{AS} = s(e^{FB}) - u_{AS}$ is greater than $\pi_S = s(e^{FB}) - u_S$ because of $u_{AS} < u_S = \bar{u}$.

Proof of Proposition 6: Suppose that reliance damages of $D = \dfrac{\bar{u} - \tilde{u}}{1-\delta}$ are imposed on the principal whenever the relationship is separated. Then, the principal's contract design problem under such termination damages is:

$$\text{(AP2)} \quad \max_{w^m, b(a), e} \pi = \frac{1-\delta}{1-\delta p_P}\left\{\int \left(a - b(a)\right) f(a \mid e) da - w^m\right\} + \frac{\delta - \delta p_P}{1-\delta p_P}(\bar{\pi} - \bar{u} + \tilde{u})$$

$$\text{s.t. } u = \frac{1-\delta}{1-\delta p_A}\left\{w^m + \int b(a) f(a \mid e) da - c(e)\right\} + \frac{\delta - \delta p_A}{1-\delta p_A}(\tilde{u} + \bar{u} - \tilde{u}) \geq \bar{u}$$

(Participation constraint for A)

$$e = \arg\max_{\tilde{e}} \int b(a) f(a \mid \tilde{e}) da - c(\tilde{e}) \qquad \text{(IC)}$$

$$-\sup_a b(a) + p_A \frac{\delta}{1-\delta}\pi \geq p_A \left\{ \frac{\delta}{1-\delta}\pi - \frac{\delta}{1-\delta}(\overline{u} - \widetilde{u}) \right\}$$

(Discretionary payment constraint for P)

$$\inf_a b(a) + p_A \frac{\delta}{1-\delta} u \geq p_A \left\{ \frac{\delta}{1-\delta}\widetilde{u} + \frac{\delta}{1-\delta}(\overline{u} - \widetilde{u}) \right\}$$

(Discretionary payment constraint for A)

As shown in proposition 3, termination damages do not change the agent's expected per-period payoff and an optimal effort level. The termination damages of *D* increase a bonus schedule by $\frac{\delta p_A}{1-\delta}(\overline{u} - \widetilde{u})$ and decrease a fixed payment by $\frac{\delta}{1-\delta}(\overline{u} - \widetilde{u})$. Thus, a bonus schedule becomes $b(a) = 0$ for all $a < \hat{a}$ and $b(a) = \frac{\delta p_A}{1-\delta}(\overline{u} - \widetilde{u})$ for all $a \geq \hat{a}$. The agent believes that a contract in which a bonus schedule and a fixed payment is adjusted like the above is self-enforcing.

However, in such a contract, participation constraint for A and discretionary payment constraint for P are not actually satisfied. When in an optimal contract from (AP2), participation constraint for A is binding, the agent's expected per-period payoff seems to be equal to $\overline{u}$. However, the agent's true expected per-period payoff is less than $\overline{u}$. For this, refer to the proof of proposition 5. Next, I check whether the principal actually does not have any incentive to default on bonus payments. The discretionary payment constraint for P that the principal recognizes is

$-\sup_a b(a) + p_P \frac{\delta}{1-\delta}\pi \geq p_P \left\{ \frac{\delta}{1-\delta}\pi - \frac{\delta}{1-\delta}(\overline{u} - \widetilde{u}) \right\}$, which is simplified to:

(A25) $\sup_a b(a) \leq \frac{\delta p_P}{1-\delta}(\overline{u} - \widetilde{u})$.

The bonus payment of $b(a)=\frac{\delta p_A}{1-\delta}(\overline{u}-\widetilde{u})$ for all $a \geq \hat{a}$ cannot satisfy (A25) because

$\sup_a b(a)=\frac{\delta p_A}{1-\delta}(\overline{u}-\widetilde{u}) > \frac{\delta p_P}{1-\delta}(\overline{u}-\widetilde{u})$ due to $p_A > p_P$. The principal can earn the

benefit of $\frac{\delta(p_A - p_P)}{1-\delta}(\overline{u}-\widetilde{u})$ by not paying the promised bonus and instead, paying the termination damages. Therefore, in a contract made under termination damages, the agent believes that paying the promised bonus is self-enforcing, whereas this is not self-enforcing for the principal.

Then, agent's true expected per-period payoff is:

(A26)
$$\begin{aligned} u_{AS.D} &= \frac{1-\delta}{1-\delta pF(\hat{a})}\left\{w^m + \int b(a) f(a \mid e_{AS}) da - c(e_{AS})\right\} + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}(\widetilde{u}+\overline{u}-\widetilde{u}) \\ &= \frac{1-\delta}{1-\delta pF(\hat{a})}\left(w^m - c(e_{AS})\right) + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}\overline{u} \end{aligned}$$

From the binding participation constraint for A and the above bonus schedule, the following fixed payment can be obtained.

(A27) $$w^m = \overline{u} + c(e) - \left(1-F(\hat{a})\right)\frac{\delta p_A}{1-\delta}(\overline{u}-\widetilde{u})$$

Substituting (A27) into (A26) yields the following agent's true expected per-period payoff under asymmetric information on an exogenous shock and the termination damages.

(A28) $$u_{AS.D} = \frac{1-\delta}{1-\delta pF(\hat{a})}\left(\overline{u} - \left(1-F(\hat{a})\right)\frac{\delta}{1-\delta}(\overline{u}-\widetilde{u})\right) + \frac{\delta - \delta pF(\hat{a})}{1-\delta pF(\hat{a})}\overline{u}$$

If $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) \geq 1$, $u_{AS.D}$ is greater than or equal to u_{AS} since

$u_{AS.D} - u_{AS} = \left[\frac{\delta(1-p)}{1-\delta p} - \frac{\delta(1-F(\hat{a}))}{1-\delta pF(\hat{a})}\right](\bar{u} - \tilde{u})$. However, $u_{AS.D}$ is still less than $\bar{u}$ since

$u_{AS.D}$ is the weighted average of $\bar{u}$ and $\bar{u} - (1-F(\hat{a}))\frac{\delta}{1-\delta}(\bar{u} - \tilde{u})$, which is less than $\bar{u}$.

On the other hand, if $\left(\frac{1-p}{1-F(\hat{a})}\right)\left(\frac{1-\delta pF(\hat{a})}{1-\delta p}\right) < 1$, $u_{AS.D}$ is less than u_{AS}.

APPENDIX B

PROOFS OF REMARKS AND PROPOSITIONS IN ESSAY 2

Proof of Proposition 1: Suppose the full review contract to achieve optimal surplus, s^* such that:

(B1) $s^* \equiv (1-\delta)E_a[a-c(e)\,|\,e] + p\delta E_a[s(a)\,|\,e] + (1-p)\delta(\tilde{u}+\overline{\pi})$.

Since s^* is optimal, $s(a) = u(a) + \pi(a) \le s^*$ and moreover, $\tilde{u} + \overline{\pi} \le s^*$. Therefore, one knows $E_a[a-c(e)\,|\,e] \ge s^*$. Now, let the agent's expected per-period payoff from the contract, $u^* \in [\overline{u}, s^* - \overline{\pi}]$ be given and define the principal's expected per- period payoff, $\pi^* \equiv s^* - u^*$. Then, I construct a termination contract that gives the same expected per-period payoffs as the original full review (non-termination) contract. Suppose that I construct a termination contract that specifies effort *e*, a fixed payment w^{m*}, a bonus schedule $b^*(a)$, and a continuation probability schedule $\alpha^*(a)$, such that the expected continuation surplus following any benefit *a* is the same as $s(a)$ under the original contract. That is, we have:

(B2) $\tilde{s} + \alpha^*(a)(s^* - \tilde{s}) \equiv s(a)$ where $\tilde{s} = \pi_{-G|x_G} + \tilde{u}$.

Let $u^*(a) \equiv \tilde{u} + \alpha^*(a)(u^* - \tilde{u})$ and $\pi^*(a) \equiv \pi_{-G|x_B} + \alpha^*(a)(\pi^* - \pi_{-G|x_B})$ be the expected continuation payoffs contingent on the benefit, *a*. Define $b^*(a)$ so that the agent's expected future payoff following contingent on the benefit, *a* is the same as that under the original contract; i.e., so as to satisfy

(B3) $b^*(a) + p\dfrac{\delta}{1-\delta}u^*(a) \equiv b(a) + p\dfrac{\delta}{1-\delta}u(a)$

Substituting $u^*(a) \equiv s^*(a) - \pi^*(a)$ and $u(a) \equiv s(a) - \pi(a)$ into (B3) yields

(B4) $-b^*(a) + p\dfrac{\delta}{1-\delta}\pi^*(a) \equiv -b(a) + p\dfrac{\delta}{1-\delta}\pi(a)$ for all *a*

, since $s^*(a) \equiv u^*(a) + \pi^*(a) \equiv \tilde{u} + \alpha^*(a)(u^* - \tilde{u}) + \bar{\pi} + \alpha^*(a)(\pi^* - \bar{\pi})$

$$= \tilde{s} + \alpha^*(a)(s^* - \tilde{s}) \equiv s(a) \equiv u(a) + \pi(a) .$$

Then, the condition for that the principal reports truthfully is satisfied.

I define a fixed payment w^{m*} such that

(B5) $w^{m*} \equiv -E_a[b^*(a) - c(e) \mid e] + \frac{1}{1-\delta}u^* - \frac{p\delta}{1-\delta}E_a[u^*(a) \mid e] - \frac{(1-p)\delta}{1-\delta}\tilde{u}$

so that the agent's expected per-period payoff u^* is

$u^* \equiv (1-\delta)E_a[w^{m*} + b^*(a) - c(e) \mid e] + p\delta E_a[u^*(a) \mid e] + (1-p)\delta\tilde{u}$.

Now I show that this termination contract $\left(w^{m*}, 0, b^*(a), \alpha^*(a), e, \pi^*, u^*\right)$ yields surplus s^* and is self-enforcing. To see this, note that the surplus s generated from the termination contract satisfies

(B6) $s \equiv (1-\delta)E_a[a - c(e) \mid e] + p\delta\{\tilde{s} + E[\alpha^*(m) \mid e](s - \tilde{s})\} + (1-p)\delta(\tilde{u} + \bar{\pi})$

, where m is the level of benefit which the principal reports.

Substituting $(1-\delta)E_a[a - c(e) \mid e] + (1-p)\delta(\tilde{u} + \bar{\pi}) \equiv s^* - p\delta E_a[s(a) \mid e]$ obtained from (B1) into (B6) yields

(B7) $s \equiv s^* - p\delta E_a[s(a) \mid e] + p\delta\{\tilde{s} + E[\alpha^*(m) \mid e](s - \tilde{s})\}$.

Substituting (B2) into (B7) yields

(B8) $s \equiv s^* - p\delta E_a[\tilde{s} + \alpha^*(a)(s^* - \tilde{s}) \mid e] + p\delta\{\tilde{s} + E[\alpha^*(m) \mid e](s - \tilde{s})\}$.

Since the principal reports benefits truthfully (i.e., $m = a$), (B8) is simplified as $s = s^*$.

Moreover, this termination contract $\left(w^{m*}, 0, b^*(a), \alpha^*(a), e, u^*, \pi^*\right)$ satisfies the constraints (i)-(vi) for self-enforcement.

Proof of Remark 1: Assume a termination contract ($w^m,\ 0,\ b(a),\ \alpha(a),\ e,\ u, \pi$) satisfies the following recursive equations,

(B9) $\pi \equiv (1-\delta)E_a[a - w^m - b(a) \mid e] + p\{\delta\pi_{-G|x_G} + \delta E_a[\alpha(a) \mid e](\pi - \pi_{-G|x_G})\} + (1-p)\delta\overline{\pi}$ and

(B10) $u \equiv (1-\delta)E_a[w^m + b(a) - c(e) \mid e] + p\{\delta\widetilde{u} + \delta E_a[\alpha(a) \mid e](u - \widetilde{u})\} + (1-p)\delta\widetilde{u}$.

When $\pi_{-G|x_G} = \pi$ and $\widetilde{u} = \overline{u}$, if the agent earns no positive rents (i.e., $u = \overline{u}$), (B9) and (B10) are simplified respectively as

(B11) $\pi \equiv \dfrac{1-\delta}{1-\delta p} E_a[a - w^m - b(a) \mid e] + \dfrac{\delta - \delta p}{1-\delta p}\overline{\pi}$ and

(B12) $\overline{u} \equiv E_a[w^m + b(a) - c(e) \mid e]$.

Therefore, the expected per-period payoffs, $\overline{u}$ and π depend on effort but not on a continuation probability schedule $\alpha(a)$. Whatever the continuation probability schedule $\alpha(a)$ is, the bonus schedule that satisfies the following three constraints (from 4-6),

(B13) $\dfrac{\delta}{1-\delta}\alpha(a)(\pi - \pi) \geq b(a)$, $\forall a \in A$ (Discretionary payment constraint for P)

(B14) $\dfrac{\delta}{1-\delta}\alpha(a)(\overline{u} - \overline{u}) \geq -b(a)$, $\forall a \in A$ (Discretionary payment constraint for A)

(B15) $\dfrac{\delta}{1-\delta}\alpha(a)(\pi - \pi) - b(a)$ is constant in a (Truthful reporting constraint)

can only be $b(a) = 0$, $\forall a \in A$. This bonus schedule cannot motivate the agent to choose any positive effort in the following incentive compatibility constraint

(B16) $e \in \arg\max_{\widetilde{e}} E_a[b(a) \mid \widetilde{e}] - c(\widetilde{e})$.

Proof of Remark 2: Consider a self-enforcing termination contract (w^m, 0, $b(a)$, $\alpha(a)$, e, u, π). One knows from truthful reporting constraint (B15), that $b(a)$ should be constant in a. One also knows from the discretionary payment constraint for P (B13), that $b(a)$ should be non-positive for all a. Then, one can conclude from the following discretionary payment constraint for A,

$$\text{(B17)} \quad \frac{\delta}{1-\delta}\alpha(a)(u-\bar{u}) \geq -b(a), \; \forall a \in A,$$

that if $\alpha(a)$ is zero for at least one $a \in A$, a bonus schedule is $b(a) = 0$, $\forall a \in A$. On the other hand, if $\alpha(a)$ is larger than zero for $\forall a \in A$, a negative constant bonus schedule such that $b : A \to -\beta$, where $\beta > 0$ is possible. However, such a bonus schedule can be replaced with a bonus schedule, $b : A \to 0$ by decreasing a fixed payment, w^m by β so that both parties' expected per-period payoffs are unchanged and self-enforcement is satisfied. Therefore, one can restrict attention to $b(a) = 0$, $\forall a \in A$.

Finally, one can conclude from the following agent's incentive compatibility constraint:

$$\text{(B18)} \quad e \in \arg\max_{\tilde{e}} E_a\left[p\frac{\delta}{1-\delta}\alpha(a)\big(u-\bar{u}\big) \mid \tilde{e} \right] - c(\tilde{e}),$$

that a continuation probability schedule should not be constant in a to ensure that the principal can motivate the agent.

Proof of Proposition 2: Part (i) follows from Remark 1. To show parts (ii)-(iv), denote the multipliers of (PC_2) and (IC_2) by λ_1 and λ_2, respectively, and the multipliers of the first and second inequalities in the double-sided boundary constraints by $\xi(a)$ and $\mu(a)$, respectively. I can write Lagrangian L of (P2) as:

$$
\begin{aligned}
& L(\alpha(a), w^m, e, \lambda_1, \lambda_2, \mu(a), \xi(a)) \\
& = \int (a - w^m) f(a \mid e) da + \lambda_1 \left\{ (1-\delta)\left(w^m - c(e) - \tilde{u}\right) - (\bar{u} - \tilde{u})(1 - p\delta \int \alpha(a) f(a \mid e) da) \right\} \\
& + \lambda_2 \left\{ p\delta (w^m - c(e) - \tilde{u}) \int \alpha(a) f_e(a \mid e) da + p\delta \int \alpha(a) f(a \mid e) da c'(e) - c'(e) \right\} \\
& - \int \mu(a) \{ \alpha(a) - 1 \} da + \int \xi(a) \alpha(a) da \; .
\end{aligned}
$$

The first-order conditions are

(B19) $\dfrac{dL}{d\alpha(a)} = \lambda_1 \{ p\delta(\bar{u} - \tilde{u}) f(a \mid e) \} + \lambda_2 \{ p\delta (w^m - c(\tilde{e}) - \tilde{u}) f_e(a \mid e) + p\delta f(a \mid e) c'(e) \} - \mu(a) + \xi(a) = 0, \forall a \in A$,

(B20) $\dfrac{dL}{dw^m} = -1 + \lambda_1 (1-\delta) + \lambda_2 p\delta \int \alpha(a) f_e(a \mid e) da = 0$,

(B21) $\dfrac{dL}{de} = \int (a - w^m) f_e(a \mid e) da + \lambda_1 \left\{ -(1-\delta) c'(e) + (\bar{u} - \tilde{u}) p\delta \int \alpha(a) f_e(a \mid e) da \right\},$

$$+ \lambda_2 \left\{ p\delta (w^m - c(e) - \tilde{u}) \int \alpha(a) f_{ee}(a \mid e) da + p\delta c''(e) \int \alpha(a) f(a \mid e) da - c''(e) \right\} = 0 ,$$

(B22) $\lambda_1 \left\{ (1-\delta)\left(w^m - c(e) - \tilde{u}\right) - (\bar{u} - \tilde{u})[1 - p\delta \int \alpha(a) f(a \mid e) da] \right\} = 0$; $\lambda_1 \geq 0$;

$$(1-\delta)\left(w^m - c(e) - \tilde{u}\right) - (\bar{u} - \tilde{u})\left(1 - p\delta\, E_a[\alpha(a) \mid e]\right) = 0 ,$$

(B23) $\mu(a)\{\alpha(a) - 1\} = 0$; $\mu(a) \geq 0$; $\alpha(a) \leq 1$ for $\forall a \in A$, and

(B24) $\xi(a) \cdot \alpha(a) = 0$; $\xi(a) \geq 0$; $\alpha(a) \geq 0$ for $\forall a \in A$.

Rearranging (B20), one can get $\lambda_1 (1-\delta) + \lambda_2 p\delta \int \alpha(a) f_e(a \mid e) da = 1$. It follows immediately that both λ_1 and λ_2 cannot be jointly zero since the LHS of the equation must be positive. Thus, we have to consider two cases. First, I consider the case of $\lambda_1 = 0$. In the extreme case where the equality of (PC_2) is excluded, (PC_2) is unbinding.

Notice from (B20) that both λ_2 and $\int \alpha(a) f_e(a \mid e) da$ cannot be zero simultaneously; thus, (B22) can be rearranged to get,

(B25) $\lambda_2 = \dfrac{1}{p\delta \int \alpha(a) f_e(a \mid e) da}$.

If $\lambda_2 > 0$ is assumed, $\int \alpha(a) f_e(a \mid e) da$ should be positive.[50] Since $\lambda_1 = 0$, (B19) becomes

(B26) $\lambda_2 \{ p\delta(w^m - c(e) - \tilde{u}) f_e(a \mid e) + p\delta c'(e) f(a \mid e) \} = \mu(a) - \xi(a), \forall a \in A$.

Note that $w^m - c(e) - \tilde{u} > 0$ should be satisfied in (PC_2) since the second term of the LHS of (PC_2) is negative.

Since $\lambda_2 > 0$, $w^m - c(e) - \tilde{u} > 0$, and $c'(e) > 0$, if either $f_e(a \mid e) \geq 0$ or $p\delta(w^m - c(e) - \tilde{u}) f_e(a \mid e) + p\delta c'(e) f(a \mid e) > 0$ and $f_e(a \mid \mathrm{e}) < 0$, then for some $a \in A$ in (B26), it must be true that $\mu(a) > 0$ and $\xi(a) = 0$. Therefore, one can conclude that $\alpha(a) = 1$ from (B23) and (B24). If $p\delta(w^m - c(e) - \tilde{u}) f_e(a \mid e) + p\delta c'(e) f(a \mid e) = 0$ and $f_e(a \mid e) < 0$ for some $a \in A$ in (B26), $\mu(a) = \xi(a) = 0$ should be satisfied since $\mu(a)$ and $\xi(a)$ cannot be positive simultaneously. Hence, $\alpha(a)$ can be any value between 0 and 1 but I set it to zero arbitrarily. If $p\delta(w^m - c(e) - \tilde{u}) f_e(a \mid e) + p\delta c'(e) f(a \mid e) < 0$ and $f_e(a \mid e) < 0$, it should be essential that $\mu(a) = 0$ and $\xi(a) > 0$. Therefore, one can conclude $\alpha(a) = 0$ from (B23) and (B24).

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[50] If $\lambda_2 < 0$, $\alpha(a)$ is also one step but reversed compared to the case where $\lambda_2 > 0$. Therefore, such a continuation probability schedule cannot provide the agent with incentives.

Next, that a continuation probability schedule is one-step can be shown by using MLRP, $\frac{\partial}{\partial a}\left(\frac{f_e(a \mid e)}{f(a \mid e)}\right) > 0$ for $\forall a \in A$. For some w^m and e, let a cut-off point, $\hat{a}$, be such that

(B27) $p\delta(w^m - c(e) - \tilde{u}) f_e(\hat{a} \mid e) + p\delta\, c'(e) f(\hat{a} \mid e) = 0$.

Rearranging (B27) yields $\frac{c'(e)}{w^m - c(e) - \tilde{u}} = -\frac{f_e(\hat{a} \mid e)}{f(\hat{a} \mid e)}$. Since the LHS is positive, $f_e(\hat{a} \mid e)$ should be negative. Therefore, $\hat{a}$ should be lower than the level of a that satisfies $f_e(a \mid e) = 0$, since $f_e(\hat{a} \mid e)/f(a \mid e)$ is increasing in a by the MRLP. For $\forall a > \hat{a}$, one has $\frac{c'(e)}{w^m - c(e) - \tilde{u}} > -\frac{f_e(a \mid e)}{f(a \mid e)}$ and $\alpha(a) = 1$. On the other hand, for $\forall a < \hat{a}$, one has $\frac{c'(e)}{w^m - c(e) - \tilde{u}} < -\frac{f_e(a \mid e)}{f(a \mid e)}$ and $\alpha(a) = 0$. This establishes (ii) and (iii).

Applying $\int f_e(a \mid e) da = 0$, $\int \alpha(a) f(a \mid e) da = 1 - F(\hat{a} \mid e)$, $\int \alpha(a) f_e(a \mid e) da = -F_e(\hat{a} \mid e)$, and $\int \alpha(a) f_{ee}(a \mid e) da = -F_{ee}(\hat{a} \mid e)$ into the equation obtained by substituting (B25) into (B21) yields

(B28) $p\delta F_e(\hat{a} \mid e) \int a f_e(a \mid e) da + p\delta(w^m - c(e) - \tilde{u}) F_{ee}(\hat{a} \mid e) + \left(1 - p\delta\left(1 - F(\hat{a} \mid e)\right)\right) c''(e) = 0$.

(IC_2) can be rewritten as

(B29) $-\delta(w^m - c(e) - \tilde{u}) F_e(\hat{a}) + \delta\left(1 - F(\hat{a} \mid e)\right) c'(e) - c'(e) = 0$.

Then, one can solve w^m, e, and $\hat{a}$ from (B27), (B28), and (B29).

Now I consider the case where $\lambda_1 > 0$, for which (PC_2) should be binding. I also assume $\lambda_2 > 0$ (see footnote 50). Dividing the equation obtained by integrating (B19) with *a* by $\int \{\mu(a) - \xi(a)\} da$ yields

(B30) $$\lambda_2 \frac{p\delta c'(e)}{\int \mu(a) - \xi(a) da} + \lambda_1 \frac{p\delta(\overline{u} - \widetilde{u})}{\int \mu(a) - \xi(a) da} = 1.$$

Comparing (B30) with (B20), one can observe two conditions,

$$\frac{p\delta c'(e)}{\int \mu(a) - \xi(a) da} = p\delta \int \alpha(a) f_e(a \mid e) da \text{ and } \frac{p\delta(\overline{u} - \widetilde{u})}{\int \mu(a) - \xi(a) da} = 1 - \delta.$$

Then, one can unite the two conditions into the following

(B31) $$\int \mu(a) - \xi(a) da = \frac{c'(e)}{\int \alpha(a) f_e(a \mid e) da} = \frac{p\delta(\overline{u} - \widetilde{u})}{1 - \delta}.$$

Dividing (B19) by $f(a \mid e)$ yields

(B32) $$\lambda_2 \left\{ p\delta(w^m - c(\widetilde{e}) - \widetilde{u}) \frac{f_e(a \mid e)}{f(a \mid e)} + p\delta c'(\widetilde{e}) \right\} + \lambda_1 p\delta(\overline{u} - \widetilde{u}) = \frac{\mu(a) - \xi(a)}{f(a \mid e)}, \forall a \in A.$$

Substituting $\lambda_1 p\delta(\overline{u} - \widetilde{u}) = -\lambda_2 p\delta c'(e) + \int \mu(a) - \xi(a) da$ from (B30) and

$\int \mu(a) - \xi(a) da = \dfrac{p\delta(\overline{u} - \widetilde{u})}{1 - \delta}$ from (B31) into (B32) produces

$$\lambda_2 \left\{ \delta(w^m - c(\widetilde{e}) - \widetilde{u}) \frac{f_e(a \mid e)}{f(a \mid e)} \right\} + \frac{p\delta(\overline{u} - \widetilde{u})}{1 - \delta} = \frac{\mu(a) - \xi(a)}{f(a \mid e)}.$$

Then, let a cut-off point $\hat{a}$ be such that $\mu(\hat{a}) = \xi(\hat{a}) = 0$ and

(B33) $$\lambda_2 \left\{ \delta(w^m - c(\widetilde{e}) - \widetilde{u}) \frac{f_e(\hat{a} \mid e)}{f(\hat{a} \mid e)} \right\} + \frac{p\delta(\overline{u} - \widetilde{u})}{1 - \delta} = 0.$$

One can derive $\alpha(a) = 1$ for all $a > \hat{a}$ and $\alpha(a) = 0$ for all $a \le \hat{a}$ by following the procedure used in the case of $\lambda_1 = 0$. From (B20), (B21), (B33), (IC_2), and binding (PC_2), one can solve $\lambda_1, \lambda_2, \hat{a}, w^m$, and *e*. Finally, part (iv) is shown because one of the two solution candidates from the cases $\lambda_1 = 0$ and $\lambda_1 > 0$ will be an optimal self-enforcing termination contract.

Proof of Proposition 3: The contract $\left(w^m, 0, 0, \alpha(a), e, \pi, u\right)$ is derived by solving the principal's contract design problem (P1) (or (P2)). When any positive severance payment w_s is imposed on the contract by regulation, the principal faces the following new problem:

(P3) $\max_{\hat{e},\hat{w}^m,\hat{\alpha}(a),\hat{b}(a)} E_a[a - \hat{w}^m - \hat{b}(a) \mid e] - \delta(1 - pE_a[\hat{\alpha}(a) \mid \hat{e}])w^s$ [51]

$$\text{s.t. } \hat{u} = \tilde{u} + \frac{1-\delta}{1 - p\delta E_a[\hat{\alpha}(a) \mid \hat{e}]} E_a[\hat{w}^m + \hat{b}(a) - c(\hat{e}) + \delta(1 - pE_a[\hat{\alpha}(a) \mid \hat{e}])w^s \mid \hat{e}] \ge \bar{u} \text{ [52]} \quad (PC_3)$$

$$\hat{e} \in \arg\max_{\tilde{e}} E_a\left[\hat{b}(a) + p\frac{\delta}{1-\delta}\hat{\alpha}(a)\left(\hat{u} - \tilde{u} - (1-\delta)w^s\right) \mid \tilde{e}\right] - c(\tilde{e}) \quad (IC_3)$$

$$p\delta\hat{\alpha}(a)w^s \ge \hat{b}(a), \quad \forall a \in A \quad \text{(Discretionary payment constraint for P)}$$

$$-p\hat{\alpha}(a)\frac{\delta}{1-\delta}(\hat{u} - \tilde{u} - (1-\delta)w^s) \le \hat{b}(a), \quad \forall a \in A \quad \text{(Discretionary payment constraint for A)}$$

$$p\delta\hat{\alpha}(a)w^s - \hat{b}(a) \text{ is constant in } a \quad \text{(Truthful reporting constraint)}$$

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[51] The objective function is obtained by transforming linearly the following
$$\hat{\pi} = \frac{1-\delta}{1-p\delta}E_a[a - \hat{w}^m - \hat{b}(a) \mid e] + \frac{\delta - \delta p}{1-p\delta}\bar{\pi} - \frac{\delta(1 - pE_a[\hat{\alpha}(a) \mid \hat{e}])(1-\delta)w^s}{1-p\delta}$$

[52] It is simplified from $\hat{u} = \frac{1-\delta}{1 - p\delta E_a[\hat{\alpha}(a) \mid \hat{e}]} E_a[\hat{w}^m + \hat{b}(a) - c(\hat{e}) \mid \hat{e}] + \frac{\delta(1 - pE[\hat{\alpha}(a) \mid \hat{e}])}{1 - p\delta E_a[\hat{\alpha}(a) \mid \hat{e}]}(\tilde{u} + w^s) \ge \bar{u}$

I use the notation $\hat{w}^m$, $\hat{b}(a)$, $\hat{\alpha}(a), \hat{e}$, and $\hat{u}$ to distinguish (P3) from (P1) and also denote an optimal self-enforcing termination contract from (P3) by $\left(\hat{w}^m, w^s, \hat{b}(a), \hat{\alpha}(a), \hat{e}, \hat{\pi}, \hat{u}\right)$.

One can derive from the discretionary payment constraints for P and A that $\hat{b}(a)$ should be zero for $\hat{\alpha}(a)=0$ when a continuation probability schedule is assumed to be one-step:

- $\hat{\alpha}(a)=0$, $\forall a \le \overline{a}$ and $\hat{\alpha}(a)=1$, $\forall a > \overline{a}$, where $\overline{a}$ denotes an arbitrary cut-off point.

Then, from the truthful reporting constraint,

(B34) $p\delta\hat{\alpha}(a)w^s - \hat{b}(a) = 0$, $\forall a \in A$.

One can also derive from (B34), that $\hat{b}(a) = p\delta w^s$ when $\alpha(a)=1$.

Substituting $\hat{b}(a)=0$ and $\hat{\alpha}(a)=0$ for all $a \le \overline{a}$ and $\hat{b}(a)=p\delta w^s$ and $\hat{\alpha}(a)=1$ for all $a > \overline{a}$ into the objective function, (PC$_3$), and (IC$_3$) yields

(B35) $E_a[a - \hat{w}^m - (1-F(\hat{a}))p\delta w^s \mid \hat{e}] - \delta(1 - p(1-F(\hat{a}))w^s = E_a[a - \hat{w}^m - \delta w^s \mid \hat{e}]$,

(B36) $\hat{u} = \tilde{u} + \dfrac{1-\delta(\hat{w}^m + \delta w^s - c(\hat{e}) - \tilde{u})}{1 - p\delta E_a[\hat{\alpha}(a) \mid \hat{e}]} \ge \overline{u}$, and

(B37) $\hat{e} \in \arg\max_{\tilde{e}} E_a\left[p\dfrac{\delta}{1-\delta}\hat{a}(a)(\hat{u}-\tilde{u}) \mid \tilde{e}\right] - c(\tilde{e})$.

Defining $\hat{\hat{w}}^m \equiv \hat{w}^m + \delta w^s$, the principal solves the following problem:

(P4) $\max_{\hat{e}, \hat{\hat{w}}^m, \hat{\alpha}(a)} E_a[a - \hat{\hat{w}}^m \mid \hat{e}]$

$$\text{s.t. } \hat{u} = \tilde{u} + \frac{(1-\delta)(\hat{\hat{w}}^m - c(\hat{e}) - \tilde{u})}{1 - p\delta E_a[\hat{\alpha}(a) \mid e]} \ge \overline{u} \qquad \text{(PC}_4\text{)}$$

$$\hat{e} \in \arg\max_{\tilde{e}} E_a\left[p\frac{\delta}{1-\delta}\hat{\alpha}(a)(\hat{u}-\tilde{u}) \mid \tilde{e}\right] - c(\tilde{e}) \qquad \text{(IC}_4\text{)}$$

$0 \le \hat{\alpha}(a) \le 1$ for $\forall a \in A$.

Since (P4) is equivalent to (P1), one knows that $\hat{e} = e$, $\hat{\hat{w}}^m \equiv \hat{w}^m + \delta w^s = w^m$, $\hat{\alpha}(a) = \alpha(a)$, $\hat{u} = u$, and $\hat{\pi} = \pi$. The cut-off point $\bar{a}$ is identical to the cut-off point $\hat{a}$ of the original contract. Therefore, $\left(\hat{w}^m, w^s, \hat{b}(a), \hat{\alpha}(a), \hat{e}, \hat{\pi}, \hat{u}\right)$ is equivalent to $\left(w^m - \delta w^s, w^s, b(a), \alpha(a), e, \pi, u\right)$, where $b(a) = 0$ and $\alpha(a) = 0$ for all $a \leq \hat{a}$, and $b(a) = p\delta w^s$ and $\alpha(a) = 1$ for all $a > \hat{a}$.[53]

[53] I use $b(a)$ instead of $\hat{b}(a)$ for simplicity of notation.

APPENDIX C

INSTRUCTIONS FOR BUYERS AND SELLERS

Instructions for Buyers

In this experiment everyone begins with $5. During the experiment you can earn more money, with the exact amount depending on you and your pair member's decisions. During the experiment, your income is calculated in points. At the end of the experiment, points are converted into dollars at the rate of:

$1 = 70 points

Your initial balance of $5 equals 350 points.

Without exception, all written information you received from us is for your private use only. You are not allowed to pass over any information to other participants in the experiment. Talking during the experiment is not permitted. Violations of these rules would force us to stop the experiment. If you have any questions, please ask us.

General Information

The experiment is divided into periods. In each period, you have to make decisions, which you will enter on a computer screen. There are 15 identical periods in all and **the experiments ends at the end of period 15.**

Participants are divided into two groups with 5 buyers and 7 sellers. **You will remain a buyer throughout the experiment.** This session will involve trading between buyers and sellers. The price agreed upon between the buyer and seller will determine how much money each party makes during the period.

Trades will take place on the computer screen. Buyers and sellers will each be identified by a number (from 1 to 7) that will change after each round. So, the numbers can be used to negotiate trades within a given round, but the numbers will not allow you to track other participants between rounds. The significance of this number reassignment is that, in each period, **no buyer or seller will be able to track with certainty the buyer or seller he/she traded with in previous periods.**

The Experimental Procedures in Detail

Each period is divided into a **trading phase** followed by a **quality determination phase** and then followed by a **price determination phase.**

1. <u>The Trading Phase</u>

Each period starts with a trading phase. During the trading phase, each buyer can conclude a trade with one seller. In order to do so **each buyer can submit as many offers as he/she wishes.** In each trading phase, you will see a screen with some of the following features:

- The trading period is indicated at the top of the screen. The remaining time in the trading phase is also indicated at the top right corner. The **trading phase will last 90 seconds.**

When the time is up, the trading phase is over and no further offers can be submitted or accepted.

- Your buyer number (which changes each **period)** is shown below the remaining time indicator.
- Once the trading screen is displayed, the trading phase starts. As a buyer, you now have the opportunity to submit offers to sellers. Offers must include the following, which is to be entered into the right hand side of the screen:

a) Specify whether the offer is to be public or private.

Public offers will be communicated to all participants, both sellers and buyers. In turn, you will see all public offers by other buyers. **A public offer can be accepted by any seller. Simply click on the "public" field to submit a public offer.**

A **Private offer** is submitted to one seller only. Only the seller will be informed of the offer and only the seller can accept the offer. **Click the "private"** field to submit a private offer. After that, you must specify which seller you want to submit the offer to by entering the seller's number.

Remember, every seller **is randomly assigned new numbers in every period so that the seller you traded with in the previous period may have a new number. This will make it difficult for you to identify sellers that you traded with previously. Also, because you are randomly assigned a new buyer number this period, the seller you traded with in a previous period will have difficulty identifying you.**

b) Specify what **price** you want to offer. Enter your price in the "Your price" field. The price can range from 0 to 100 (whole numbers only).

c) Specify what **quality** you desire. Enter this in the "Desired quality field". Quality can range from 0 to 10, where higher numbers are better (whole numbers only).

After specifying the type of offer, the price, and the quality, click "OK" to submit it.

- On the left side of your screen, you will see the header "public offers," which displays all public offers made by buyers, including your own offer.
- In the middle of the screen, you can see all private offers that you have submitted in the current trading phase.
- **Each buyer can submit as many private and public offers as he wishes in each period.** Each offer that you submit can be accepted at any time during the trading phase.
- **In any given period, each buyer can conclude at most one trade.** Once one of your offers has been accepted, you will be notified which seller accepted which of your offers. This information will be displayed on the bottom right corner of your screen. At this point, all your other offers will be removed from the market and cancelled.
- **In any given period, each seller can conclude at most one trade.** You will be continuously informed about which sellers have not yet accepted an offer. On the bottom right of the screen, you will see 7 fields, each field for one of the 7 sellers. Once a seller has accepted an offer, an "x" will appear in the field next to the seller's number. You cannot submit private offers to a seller who has already concluded a trade.

- Once all 5 buyers have concluded a trade or after time has elapsed, the trading phase is over.
- No buyer is obliged to submit offers, and no seller is obliged to accept an offer.

2. Quality Determination Phase

- Following the trading phase, all **sellers** who have concluded a trade will determine the level of quality that they will supply to their buyers. **The product quality you asked for in your offer is not binding for your seller –** i.e. your seller can choose any quality he/she wants to from 0 to 10.

- While your seller is determining quality, you are asked to specify which quality you *expect* him/her to supply. In addition, we ask you to state how certain you are that the seller will actually deliver the quality you expect.

3. Price Determination Phase

- Following the quality determination phase, each **buyer** who has concluded a trade will determine the actual price that will be paid to his/her seller. **The price you promised in your offer is not binding –** i.e., at this point you can choose any price you want from 0 to 100. Note that the buyer will observe the quality provided by the seller before the buyer chooses his/her price.

- While you finalize your price, your seller is asked to specify which price he/she *expects* that you will pay. In addition, the seller is asked to state how certain he/she is that the expected price will be paid.

How Are Points (Income) Calculated?

Your Points

- If you do not conclude a trade during the trading phase, you will receive 0 points for that period.
- If one of your offers is accepted, your points depend on the price you choose to pay during the price determination phase and on the actual product quality delivered. Your points for that period are determined as follows:

Your Points = 10*Product Quality – Price

- As you can see, the higher the product quality, the more points you earn. At the same time, the lower the price you paid, the more points you earn.
- In summary, higher quality at lower prices means more points for you.

How do Sellers Earn Points?

- If a seller has not concluded a trade during the trading phase, he/she gains 10 points for that period.
- If the seller has accepted an offer, his/her income equals the price he/she receives minus the production costs he/she incurs. The income of a seller is determined as follows:

Points = Price – Production Costs

- As you can see, the higher the price, the more points a seller earns. At the same time, the higher the quality, the higher the production costs, which reduces points.

- How are production costs calculated? The higher the quality the seller supplies, the higher the costs. All sellers have the following cost table:

Quality	1	2	3	4	5	6	7	8	9	10
Cost	0	1	2	4	6	8	10	12	15	18

Points for all buyers and sellers are determined in the same way. **Each buyer can therefore calculate the income of his/her seller and each seller can calculate the income of his/her buyer.**

Please note that buyers and sellers can incur losses in each period (lose rather than gain points). These losses are subtracted from your points balance.

After the quality and price determination phases are complete, you will be informed about your points and the points of your seller in each period on an "**income screen**." The following information is displayed on this screen:

- the price you offered
- your desired quality
- the product quality you actually received from your seller.
- the price you actually chose.
- the points earned (lost) by your seller in this period.
- the points that you earned (lost) in this period.

Please enter all the information on the screen in the documentation sheet supplied to you. This will help you keep track of your performance across periods. After the income screen has been displayed, the period is over. Another period begins, starting with a trading phase. Once you have finished studying the income screen, please click "continue". All sellers also see an income screen displaying the same information.

Before we begin the experiment, we ask all participants to complete a questionnaire which will test your familiarity with the procedures. The experiment will not begin until all participants are completely familiar with all procedures.

In addition, we will conduct **2 trial periods of the trading phase** so that you can get accustomed to the computer. During the trial periods, no money can be earned.

Instructions for Sellers

In this experiment everyone begins with $5. During the experiment you can earn more money, with the exact amount depending on you and your pair member's decisions. During the experiment, your income is calculated in points. At the end of the experiment, points are converted into dollars at the rate of:

$1 = 70 points

Your initial balance of $5 equals 350 points.

Without exception, all written information you received from us is for your private use only. You are not allowed to pass over any information to other participants in the experiment. Talking during the experiment is not permitted. Violations of these rules would force us to stop the experiment. If you have any questions, please ask us.

General Information

The experiment is divided into periods. In each period, you have to make decisions, which you will enter on a computer screen. There are 15 identical periods in all and **the experiments ends at the end of period 15.**

Participants are divided into two groups with 5 buyers and 7 sellers. **You will remain a seller throughout the experiment.** This session will involve trading between buyers and sellers. The price agreed upon between the buyer and sell will determine how much money each party makes during the period.

Trades will take place on the computer screen. Buyers and sellers will each be identified by a number (from 1 to 7) that will change after each round. So, the numbers can be used to negotiate trades within a given round, but the numbers will not allow you to track other participants between rounds. The significance of this number reassignment is that, in each period, **no buyer or seller will be able to track with certainty the buyer or seller he/she traded with in previous periods.**

The Experimental Procedures in Detail

There are 5 buyers and 7 sellers. **You are a seller for the whole experiment.** During the experiment, all your decisions will be entered on your computer screen. The following describes in detail how you will make decisions within each period of the experiment. Each period is divided into a **trading phase** followed by a **quality determination phase** and then a **price determination phase**.

1. <u>The Trading Phase</u>

Each period starts with a trading phase. During the trading phase, each buyer can conclude a trade with one seller. To do this, the buyers can submit offers to sellers. As a seller, you can, in each period, accept one of the offers. During the trading phase, you will see a screen with the following features:

- The top left corner indicates the trading period that you are in. In the top right corner, you see the remaining time in the current trading phase, displayed in seconds. **The trading phase in each period lasts 90 seconds.** When the time is up, the trading phase is over and no further offers can be submitted by the buyer or accepted by the seller in the period.
- Your seller number (which changes each **period)** is shown near the top of the screen.
- Once the above screen is displayed, the trading phase starts. As a seller, you now accept offers submitted by the buyers. There are two types of offers that you can accept:

  a. **Private offers to you**. Each buyer can submit a private over only to you, if he/she chooses. If a buyer submits a private offer to you, **you alone will be informed about the offer and you alone can accept it.** If you receive private offers, they will appear on the left side of your screen, below the header "Private Offers to you." For each private offer, you will be informed of the buyer number of the buyer, the price offered, and the product quality desired. If you want to accept the offer, click the row in which the offer is displayed to highlight the offer. Then click the "accept" button at the bottom of the screen. Note that once you click the "accept" button, you cannot alter your choice anymore.

  b. **Public Offers.** Each buyer can also submit public offers. When a buyer submits a public offer, all sellers are informed about these offers and **any seller can accept them.** All public offers are displayed on the right side of the screen, below the header "public offers." For each offer, the buyer's number, the price offered, and the desired quality are displayed. All other buyers and all sellers see this information. If you want to accept a public offer, click the row that it is in to highlight it. Then click the "accept" button at the bottom right corner. Once you click the accept button, you cannot alter your choice anymore.

  Remember, every buyer **is randomly assigned new numbers in every period so that the buyer you traded with in the previous period may have a new number. This will make it difficult for you to identify buyers that you traded with previously. Also, because you are randomly assigned a new seller number this period, the buyer you traded with in a previous period will have difficulty identifying you.**

- Once you accept an offer, the offer will be displayed on the bottom of the screen.
- **Each seller can conclude at most one trade in each period.** Thus, once you accept an offer, you cannot accept any other offers.
- **All buyers have to observe the following rules when submitting offers:**

  a) The price can range from 0 to 100 (whole numbers only).

  d) The **desired quality** of the buyer can range from 0 to 10, where higher numbers are better (whole numbers only).

- **Each buyer can, in each period, submit as many private and public offers as he/she wishes.** Each offer submitted by a buyer can be accepted at any time during the trading phase.
- **Each buyer can conclude at most one trade per period.** Once an offer has been accepted, the buyer will be informed about which seller accepted the offer. Because buyer can conclude only one trade per period, his/her other offers will automatically be canceled and no additional offers can be submitted.
- Once all 5 buyers have concluded a trade or after time has elapsed, the trading phase is over.
- No buyer is obliged to submit offers, and no seller is obliged to accept an offer.

2. <u>Quality Determination Phase</u>

- Following the trading phase, all **sellers** who have concluded a trade will determine the level of quality that they will supply to their buyers. **The product quality desired by your buyer is not binding for you as a seller.** That is, you can choose to supply the quality desired by your buyer or you can choose either a higher or lower quality. The only constraint on you is that the quality you choose must range from 1 to 10.
- On the screen where you are prompted to choose quality, you must enter the value for quality in the field "Choose the actual quality" and then click "OK." Once you click "OK" your decision is final and cannot be altered.
- As a reminder, the quality you choose must range from 1 to 10 and be a whole number

3. <u>Price Determination Phase</u>

- Following the quality determination phase, each **buyer** who has concluded a trade will determine the actual price that will be paid to his/her seller. **The price promised in the buyer's offer is not binding –** i.e., at this point (after quality has been determined) the buyer can choose any price from 0 to 100. Note that the buyer will observe the quality provided by the seller before the buyer chooses his/her price.

- While the buyer finalizes price, each seller is asked to specify which price he/she *expects* that will be paid. In addition, each seller is asked to state how certain he/she is that the expected price will be paid.

How Are Points (Income) Calculated?

<u>Your Points</u>

- If you did **not** conclude a trade during the trading phase, you gain 10 points for that period.
- If you accepted an offer, your income (points) equals the price you receive in the price determination phase minus the production cost that you incur. Your income is calculated as:

Points = Price – Production Costs

- As you can see, the higher the price, the more points you earn. At the same time, the higher the quality that you supply, the higher the production costs, which reduces your points.

- How are production costs calculated? The higher the quality that you supply, the higher the costs. All sellers have the following cost table:

Quality	1	2	3	4	5	6	7	8	9	10
Cost	0	1	2	4	6	8	10	12	15	18

- In summary, higher price and lower quality means more points.

<u>How do Buyers Earn Points?</u>

- If a buyer does not conclude a trade during the trading phase, he/she will receive 0 points for that period.
- If a buyer's offer is accepted, his/her points depend on the price he/she offered and on the product quality. His/her points for that period are determined as follows:

Points = 10*Product Quality – Price

- As you can see, the higher the product quality, the more points a buyer earns. At the same time, the higher the price paid, the fewer the points the buyer earns.

Please note that buyers and sellers can incur losses in each period (lose rather than gain points). These losses are subtracted from their point balances.

Points for all buyers and sellers are determined in the same way. **Each buyer can therefore calculate the income of his/her seller and each seller can calculate the income of his/her buyer.**

You will be informed about your points and the points of your buyer in each period on an "**income screen**." The following information is displayed on this screen:

- the price that was offered to you
- your buyer's desired quality
- the product quality that you actually chose.
- the price the buyer actually chose.
- the points earned (lost) by your buyer in this period.
- the points that you earned (lost) in this period.

Please enter all the information on the screen in the documentation sheet supplied to you. This will help you keep track of your performance across periods. After the income screen has been displayed, the period is over. Another period begins, starting with a trading phase. Once you have finished studying the income screen, please click "continue". All buyers also see an income screen displaying the same information.

Before we begin the experiment, we ask all participants to complete a questionnaire which will test your familiarity with the procedures. The experiment will not begin until all participants are completely familiar with all procedures.

In addition, we will conduct **2 trial periods of the trading phase** so that you can get accustomed to the computer. During the trial periods, no money can be earned.

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